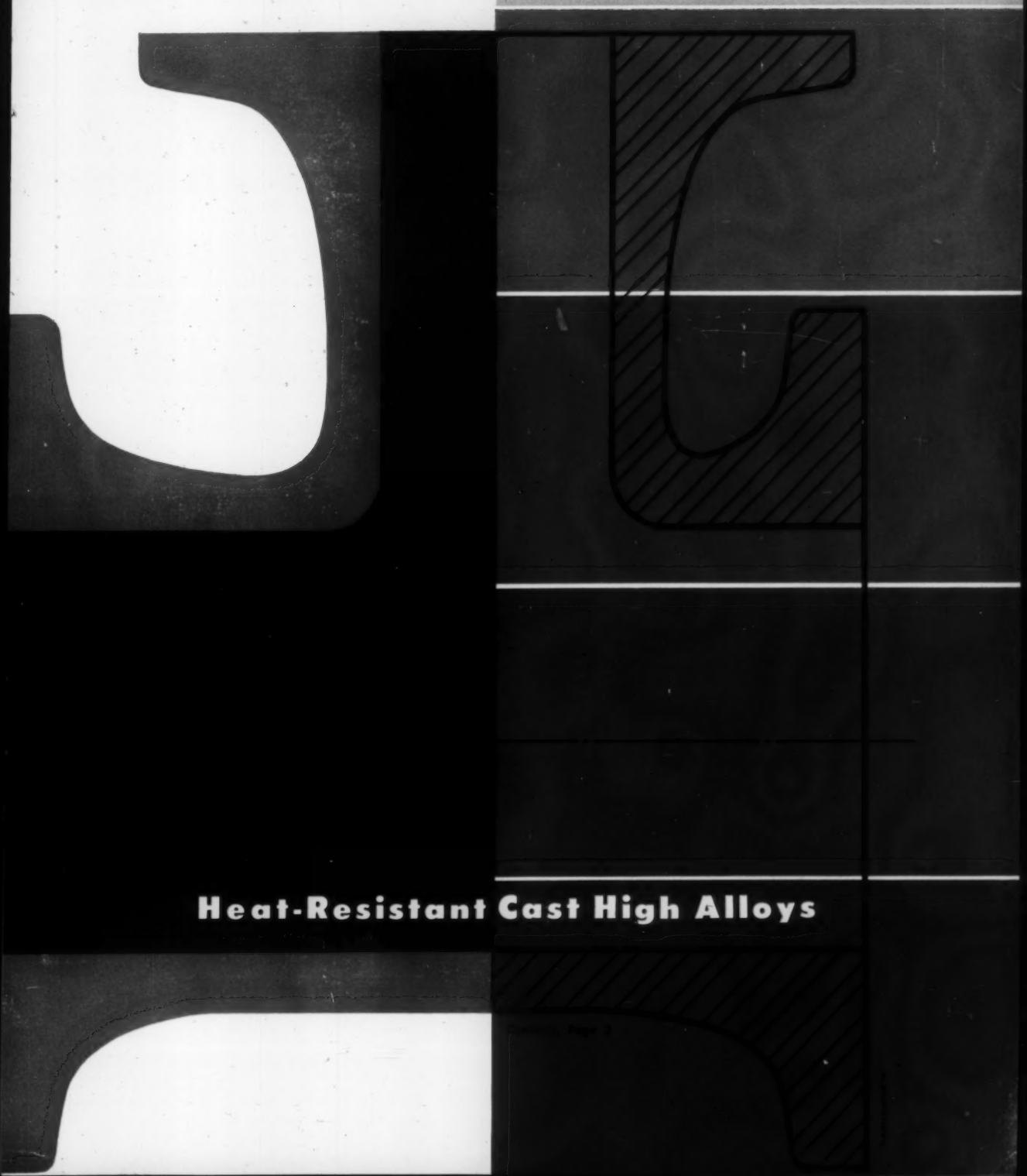
APRIL 2, 1959

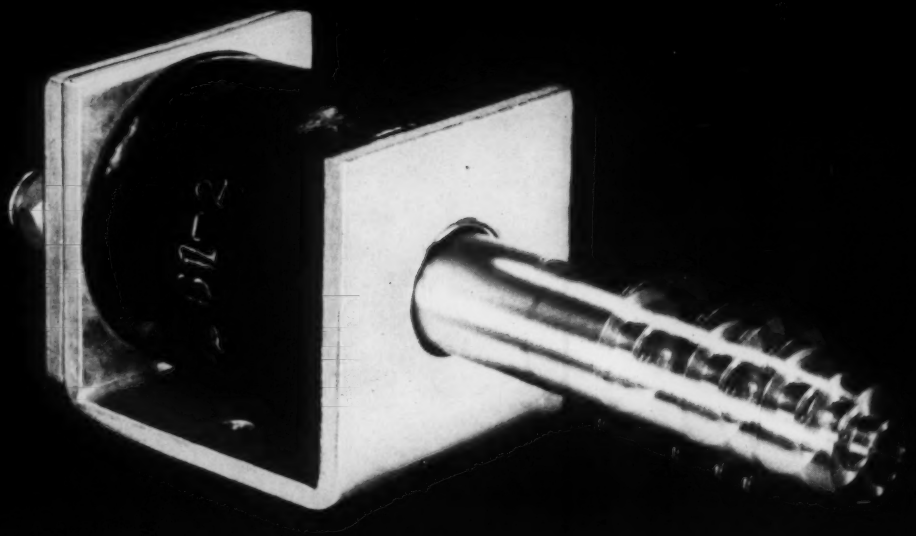
MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



Heat-Resistant Cast High Alloys

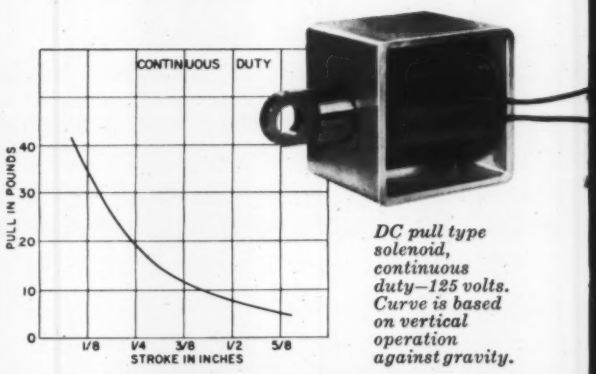
100 MILLION OPERATIONS!



new ASCO solenoid has virtually unlimited life!

This is ASCO's new long-life solenoid. Unlike ordinary solenoids where plunger rides loosely in the sleeve this device is precision manufactured to tolerances of ± .0005". A rugged machine tool bearing guides plunger to provide accurate, smooth stroking. There is virtually no wear—almost unlimited solenoid life.

If your application calls for a precision solenoid that must operate consistently and indefinitely, investigate this new long-life ASCO design. ASCO solenoids are available to meet a wide variety of applications. For additional information contact your ASCO engineer or write for Catalog 57-S5.



DC pull type solenoid, continuous duty—125 volts. Curve is based on vertical operation against gravity.

Automatic Switch Co.

54-A Hanover Road, Florham Park, New Jersey • FRontier 7-4600

AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

ASCO®

Circle 401 on Page 19

SWEET KISSES FOR SWEET CHARITY
PRESS BOTH SIDE BUTTONS AT THE SAME TIME TO RAISE SEPARATING SCREEN
KISSES $1.00
KISSES $1.00

What? Air Polices the Hands Off Policy!

We are not serious, but—

The boys might forget that a kiss doesn't involve the hands but this circuit doesn't. The screen takes care of this. When both his hands depress the actuator buttons, they start the sequence to lift the screen, but "sneaking" one hand off calls for the screen to again guard Miss "Belle-of-the-Bazaar." Our society is pretty romantic so we doubt if this "automatic bolster" will ever become popular. But as a safety feature on presses, brakes and shears the Ross non-tie-down valve, designed to keep both the operator's hands occupied, should become popular.

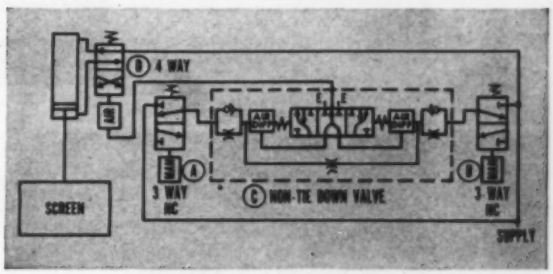
If you are interested in "two-hand safety" you are interested in a Ross non-tie-down valve.

If the operator follows instructions, then two three-way valves, either in series or in parallel, can protect his hands to a degree; but the *operator* who sets his mind to it, can beat either of these hook-ups and keep one hand free. This valve is designed to avoid one hand operation. In the Ross non-tie-down circuit, both three-way button valves are depressed at once to initiate an action and both released before another action can be initiated.

ROSS OPERATING VALVE CO.

109 E. Golden Gate Ave. • Detroit 3, Michigan

The Ross non-tie-down valve is just one of the many designed by Ross to assist in creating safer press circuits. Call your nearby Ross engineer or write for full details.

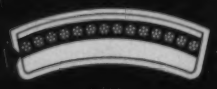


SEQUENCE OF OPERATIONS

- **Operating valves "A" and "B" simultaneously permits air to flow through the valve "C", shifting valve "D". Valve "D" operates cylinder raising screen.**
- **De-actuating valves "A" and "B" simultaneously de-actuates valves "C" and "D". Cylinder retracts and valve "C" re-sets itself for another cycle.**
- **Operating either valve "A" or "B" independently will *not* cause valve "C" to pass actuating air to valve "D".**
- **De-actuating either valve "A" or "B" independently, causes pilot air to valve "D" to be exhausted through valve "C". After that occurs both valves "A" and "B" must be released to re-set valve "C" before it will pass air to valve "D" again.**

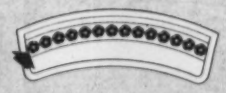
Circle 404 on Page 19

Positive Load Transfer



The special "floating gum" insulating section transfers the load to the carrying cords—prevents chafing.

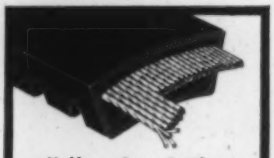
True Dimensional Stability



It's muscled by the exclusive Triple-Tempered (3-T) Cord to give you true dimensional stability in storage and in service.

Highest Transverse Rigidity

The special compression section of fiber-reinforced synthetic rubber strongly resists dishing under side pressure—protects from undue fatigue.



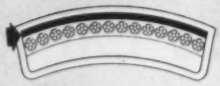
Uniform Cross Section

Precision molding assures an always uniform cross section throughout the length of each belt.

NOW—AN INVARIABLE CURE

to variable speed drive headaches

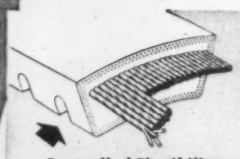
Assured Balance of Yield



The special "cool-running" tension section makes the top of the belt yield in exactly the opposite direction as the bottom—equalizes pull on either side.

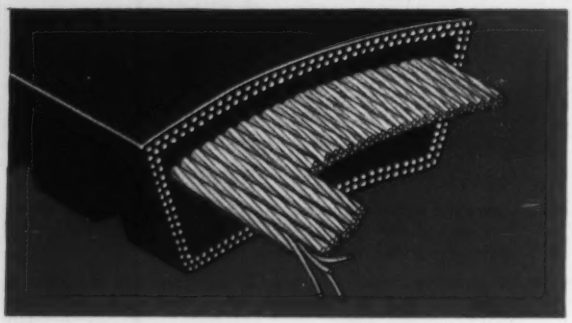
Excellent Gripping Ability

The specially compounded, highly abrasion-resistant cover assures a strong, uniform grip on both faces of the sheave.



Controlled Flexibility

Completely uniform notching gives you the flexibility to bend over small pulleys—without sacrifice of cross-rigidity or strength.



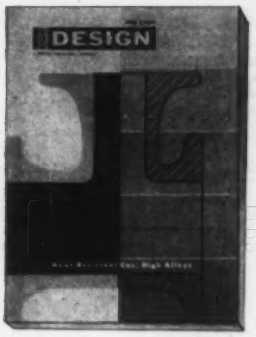
HERE, at last, is a belt with all the answers to one of your toughest of belting problems: harnessing variable speed drives. It's the great new Goodyear Variable Speed Belt—developed through years of research and testing.

And it brings you all the Goodyear *extra-quality* features that assure the maximum, trouble-free horsepower hours at minimum cost. For more details, contact the G.T.M. – Goodyear Technical Man – through your Goodyear Distributor. Or write Goodyear, Industrial Products Division, Akron 16, Ohio.

VARIABLE SPEED BELTS by **GOODYEAR**

THE GREATEST NAME IN RUBBER

Circle 405 on Page 19



Front Cover: Besides answering some tough design problems, castings for service at over 1200 F make a colorful theme for this issue's cover. E. A. Schoefer's article on Page 118 tells how to choose the best alloy for the job.

April 2, 1959

Powerhouse in a Capsule 22

EDWARD F. MAYER—*News Report*—Unconventional sources of power that generate electricity without moving parts may be the answer to tomorrow's energy-generation needs.

Measuring Motion with High-Speed Movies 102

WILLIAM G. HYZER—Techniques and equipment for accurate, on-the-spot qualitative and quantitative analysis of the performance of moving machine parts.

Cycloidal-Crank Mechanisms 111

E. H. SCHMIDT—How to get intermittent or irregular motion with various forms of crank mechanisms that generate cycloidal, epicycloidal, or hypocycloidal displacements.

Heat-Resistant Cast High Alloys 118

E. A. SCHOEFER—A guide to selection of iron-chromium-nickel casting alloys for structural parts in applications where temperatures exceed 1200 F.

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Using Rubber Grommets 133

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Simplified Column Design 135

HELMUT G. HOESCHEL—*Data Sheet*—A fast, straightforward method for finding the best cross-sectional dimensions of long, slender members under compression.

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MACHINE DESIGN

April 2, 1959
Volume 31 — No. 7

A Premium for Competence 101
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Engineering News 6
Fourth Design Engineering Show opens May 25 in Philadelphia—Underwriters Lab rules out burnable plastics in appliances—tiny "new-look" tubes challenge transistor markets—collective bargaining is no answer, say most engineers—photoactive matrix speeds up punched-card readout—electrostatic chuck clamps nonmetals—Investment Casting Institute will organize research pool.

Scanning the Field for Ideas 109
Knurl-broached assembly surfaces—dual four-bar linkage mechanism.

Design in Action 115
Rotating mixing-screw member is revolved in conical pattern—hydraulically powered steering cables from trailer pivot whole tractor.

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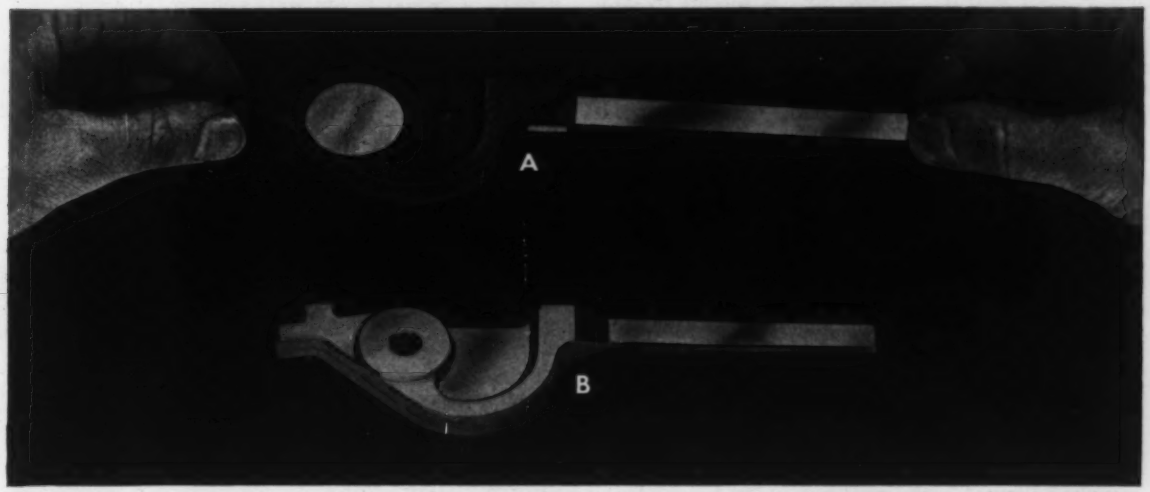
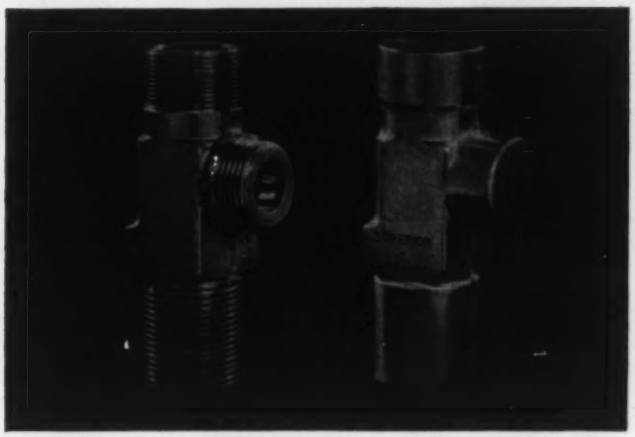
QUALITY CONTROL PLUS SAVINGS Value analysis suggested the use of a die-pressed forging. The result: an 85% cost reduction and a stronger, tougher part.



SWITCH BLADE in overspeed limiting device on large General Electric motor-generators was originally an assembly **A**—an arm brazed to a brass casting which was machined, slotted, and drilled. After review in the company's Value Analysis program, assembly was replaced by Anaconda die-pressed brass forging **B**. The superior strength of twice-wrought metal made possible a one-piece part. The excellent finish and consistent dimensional accuracy of the die-pressed forgings eliminated all machining but the drilling operation. The over-all cost is 15% of the original part.



VALVES FOR CHLORINE AND FLUORINE shipping containers must have unusual corrosion resistance and high strength. Superior Valve & Fittings Co., Pittsburgh, specialists in handling halogens, looked for a forging alloy that would be suitable. American Brass Company metallurgists suggested die-pressed forgings of a slightly modified Everdur®-1014, an aluminum-silicon bronze, for this chlorine-fluorine service, and this customer is finding wide use for it in other severe service, too. The twice-wrought metal of Anaconda die-pressed forgings has dense structure to prevent leaks—strength and toughness to take rough handling. Yet it can be machined in automatic-chucking machines resulting in good cost control.

THE vital job of controlling quality *and* costs may be easier than you think. Anaconda technical specialists will gladly help you find the right alloy and mill form to do both. See your American Brass Company representative or write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 5940

DIE-PRESSED FORGINGS SPECIAL-SHAPE TUBES
EXTRUSIONS FABRICATED METAL PARTS

products of

ANACONDA®

made by The American Brass Company

ENGINEERING NEWS

Thimble-Size Tubes Aim at Transistor Markets

RCA Calls Nuvistor Development Major Component Breakthrough

NEW YORK—Tempo of the tube vs. transistor competition steps up another notch with RCA's announcement of a new family of thimble-sized electron tubes. Called Nuvistors (for new look), the miniaturized units are said to represent a major breakthrough in tube size, performance, power drain, and reliability.

RCA will furnish developmental samples to the electronics industry within the next several months, according to D. Y. Smith, general manager of RCA's Electron Tube Div. First offerings will be a small-signal triode and a small-signal tetrode. A Nuvistor beam power tube will follow. According to present plans, limited commercial production will begin in 1960 at prices that are expected to be competitive with other tubes and transistors.

Ruggedness of the tiny tube was demonstrated by tests in which it continued to operate while switched back and forth from a 660-F furnace to a −320-F liquid-nitrogen bath. Nuvistor triodes have undergone half sine-wave shocks at 67.5 g with a duration of 11 millisec without shorting. Other samples stood up well under 500-g impact for 0.75 millisec perpendicular to the long axis of the tube. Useful life of the new tubes is expected to exceed 10,000, or perhaps even 100,000 hr.

Designed to permit a high degree of mechanized assembly, Nuvistors are said to have these construction advantages: 1. Cylindrical symmetry, plus rigid cantilever construction. 2. Joints brazed at white heat (2000 F). 3. No mica parts to fray under vibration. 4. Superclean structure. 5. No glass to limit the processing temperature.

Collective Bargaining Favored By One Engineer in Five

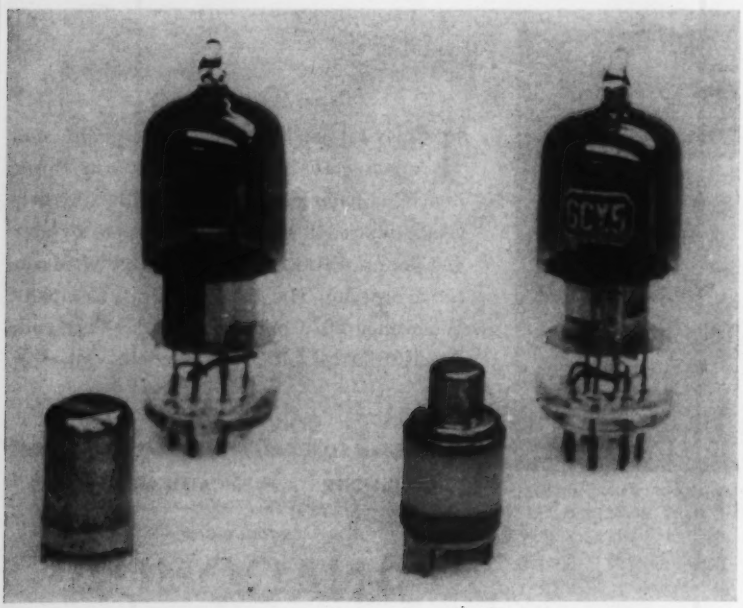
Advocates Divided on Assignment Of Bargaining Responsibility

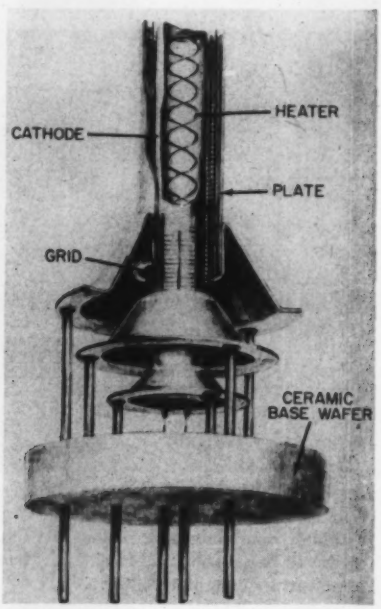
ANN ARBOR, MICH. — Improving salary and social status by collective action is favored by a "sizable minority" of scientists and engineers, according to a survey by the University of Michigan.

Interviews of more than 250 engineers and scientists employed by ten major firms show that 18 per cent of these unorganized professionals are in favor of some form of collective bargaining. About half —10 per cent—think in terms of unions, and the rest would have their professional societies collect and distribute salary and related information to members and management.

Some conclusions of the survey are:

- Attitudes of both scientists and





Big step toward miniaturization is dramatized by this comparison of RCA's Nuvistor triode and tetrode tubes with their present-day counterparts. The new-look tubes outperform the conventional models they will eventually replace. Construction of the Nuvistor (right) starts with a ceramic base-wafer which serves as a platform. Concentric electrode assemblies are erected on the platform, each solidly supported by a tripod-like structure.

. . . Fluid Power news

REPORT NO. 12,103
"HYTAC"* SYSTEMS ON NEW PAPER MACHINE

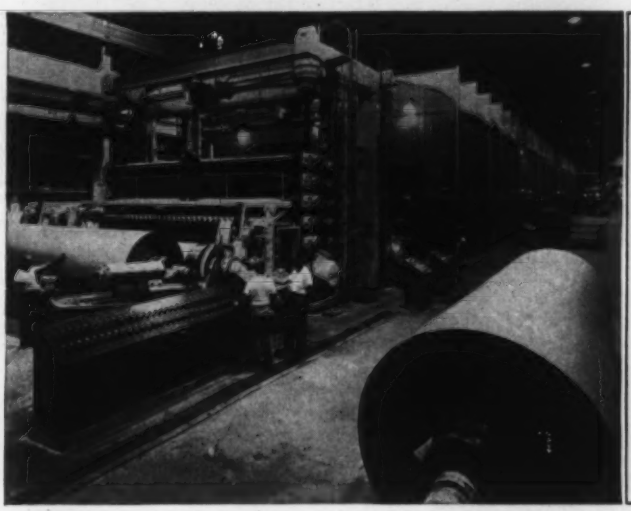
From Oilgear Application-Engineering Files

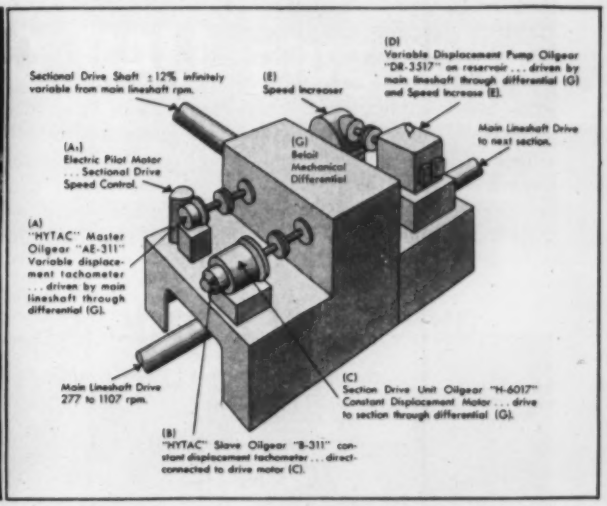
HOW OILGEAR "*ANY-SPEED*" DRIVES ON NEW PAPER MACHINE ACCURATELY CONTROL SECTION SPEEDS

USER: *West Virginia Pulp and Paper Company (Westvaco) (Builder—Beloit Iron Works, Beloit, Wisconsin)*

DATA: Systems to individually vary and accurately control speeds on four sections of a new, 264-in., $25,000,000 paper machine that will produce up to 225 tons daily of a revolutionary, patented, smooth, extensible kraft sheet. Machine is powered from a block-long main lineshaft with mechanical differentials at each section. Main lineshaft speed will vary over a 4:1 range—from 277 to 1107 rpm.

REQUIREMENTS: 1. A system that, when applied to each of four mechanical differentials, will provide individual, precision-controlled, infinitely variable increase or decrease of 10% over or under main lineshaft speed—as selected from 2 local, and 7 remote pushbutton stations. 2. Each system to maintain selected speed for its section within ±0.25% max. variation over a 50% load change at max. lineshaft speed. 3. Systems must also be: a. Compact. b. Impervious to moisture and daily high-pressure "wash-down." c. Thrifty on electrical power input. d. Trouble-free for continuous, heavy-duty, full-production paper machine drive service.




(D) Variable Displacement Pump Oilgear "DR-3517" on reservoir . . . driven by main lineshaft through differential (G) and Speed Increase (E).
Sectional Drive Shaft ±12% infinitely variable from main lineshaft rpm.
(E) Speed Increaser
Main Lineshaft Drive to next section.
(A1) Electric Pilot Motor . . . Sectional Drive Speed Control.
(G) Beloit Mechanical Differential
(A) "HYTAC" Master Oilgear "AE-311" Variable displacement tachometer . . . driven by main lineshaft through differential (G).
Main Lineshaft Drive 277 to 1107 rpm.
(C) Section Drive Unit Oilgear "H-6017" Constant Displacement Motor . . . drive to section through differential (G).
(B) "HYTAC" Slave Oilgear "B-311" constant displacement tachometer . . . direct-connected to drive motor (C).

SOLUTION: *Application-Engineered* Oilgear *Hytac** (hydraulic tachometer) controlled drives provide precise, individual speed control on each of four sections—3rd dryer, 1st calender, 2nd calender, and winder reel of Westvaco's new #3 kraft machine shown above. Drawing, above right, shows components of typical sectional drive. *These highly accurate, compact, heavy-duty systems have met or exceeded all originally specified requirements.* Examples: 1. Specified ±10% infinitely variable sectional speed control range exceeded by providing ±12% in actual operation. 2. Selected speeds are maintained within specified limits *regardless* of load change. 3. Production speeds increased to over 2000 fpm. Important "Oilgear-plus" features are: 1. Dual winder control that, with the mere flip of a control panel switch, converts winder drive from speed-controlled to tension-controlled . . . speed control prevents tearing the tail strip when starting a new core, while tension control provides good roll quality at full sheet width. 2. Cushioned, controlled acceleration and deceleration. 3. Positive overload protection. 4. Pressure and flood lubrication with continuous power fluid filtration.

OPERATION: Fluid from master tach (A) gives section drive speed command to control on pump (D). Slave tach (B) feeds back a flow signal proportional to actual section drive speed. When main lineshaft speed is increased or decreased, fluid flow from master tach (A) automatically increases or decreases to command section drive to follow lineshaft speed change. Through local or remote pushbutton stations connected to electric pilot motor (A_1) on master tach (A), operator can increase or decrease speed of each *Hytac* section infinitely up to 12% of prevailing lineshaft speed.

A second Westvaco kraft machine will have an *Application-Engineered* Oilgear Controlled Motion System to cover a 10:1 lineshaft speed range, and a wider sectional speed range adjustment.

Circle 407 on Page 19

*"HYTAC" Systems—An Oilgear Trademark

Left: Oilgear Sectional Drive Pump (D) with integral reservoir. *Right:* Oilgear Sectional Drive Motor (C) with direct-connected *Hytac* slave (B) to left.

Fluid Power drives and controls were selected after three years of development on this process and machine—from a 2-in. table model, through a 15-in. laboratory model and 60-in. pilot model. Conventional variable speed drives could not provide the sectional speed control required. "*Equipped with the most advanced precision controls known to the industry . . .*"—is the statement Westvaco has made concerning their new #3 machine.

. . . for the lowest cost per year—it's Oilgear!

For similar practical solutions to YOUR linear or rotary Controlled-Motion problems, call the factory-trained Oilgear Application-Engineer in your vicinity. Or write, stating your specific requirements, directly to . . .

THE OILGEAR COMPANY

Application-Engineered Controlled Motion Systems

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engineers toward collective bargaining are essentially the same.

- No significant relationship exists between ratings of an individual's performance and his attitude toward collective bargaining.
- There is a high relationship between an individual's feelings about his salary and his views on collective bargaining.
- Wide differences in attitudes toward collective bargaining — based largely upon satisfaction with salary and treatment by management—are found among scientists and engineers working for different firms.

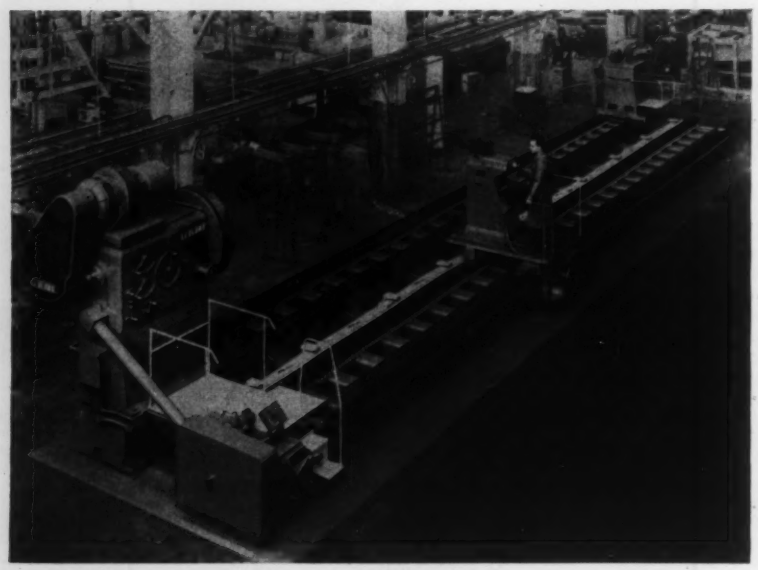
Of those who want professional societies to go to bat for them, several feel the society should find out members' opinions and make them known to management. Others feel societies should do more to advocate and police professional standards and should use publicity to a greater extent to build prestige.

Professor John W. Riegel, director of the U-M Bureau of Industrial Relations, believes that the assumption of bargaining functions by established professional societies is "improbable," since membership includes employers and managers.

On the anti-union side of the question, 50 per cent of those interviewed were strongly opposed to any form of collective bargaining, and 29 per cent were mildly opposed to the idea. Three per cent had no opinion. Main reasons given for opposition are:

- It is unnecessary, would offer no advantages, and might even be harmful.
- Salaries and promotions would not reflect an individual's responsibilities, performance, or qualifications.
- It would reduce professional productivity and development.

Other objections include fear that collective bargaining might introduce "objectionable policies and practices of labor unions," restrict personal freedom of the professionals, impair their relationship with management, and reduce their status in the community.



Two-Track Lathe Will Have Traveling Operator

First double-bed lathe ever built in the U. S. will handle a workpiece 45 ft long and almost 9 ft in diameter. Designed and built by LeBlond Machine Tool Co. for Aerojet General Corp., the big machine will presumably be used for turning large, lightweight pieces—for missiles and rockets—since it is equipped with only a 50-hp adjustable-speed motor. By ordinary lathe standards, this compares to powering a locomotive with an automobile engine. Turning speeds range from 1 to 110 rpm, with feeds as low as 0.01 in. per revolution. Operator of the machine rides down the "main line" on the lathe carriage.

Topics

Nylon resin rescues duffers with the introduction of a new golf ball. The ball has a marble-sized core of Du Pont's Zytel instead of the conventional liquid or rubber center. Makers of the Ram ball (Brass Ram Corp., Bay City, Mich.) claim the "center with a memory" keeps the ball from losing its shape after prolonged use. Also, nylon's resilience and ability to recover from impact are said to increase the effective power of the club against the ball—to the tune of an extra 10 or 20 yards to the average drive.

• • •

Sports-car smorgasbord is offered to the U. S. fancier. According to "The Foreign Car Shoppers Guide," 165 different models of foreign automobiles are available in this country.

• • •

Pliability predictor, a new testing instrument, simulates action of wrapping paper or similar material around an object and then measures the material's resistance to this operation. A 10-in. diam test sample is placed beneath a metal ring in American Instrument Company's Pliability Tester, and a domed piston is driven upward to force the sample through the ring. Pliability of the sample is indicated by force exerted on the piston and read on a dial gage calibrated in pounds.

• • •

Far-out commercials may some day be beamed at us from satellites, privately owned for advertising purposes. According to Minnesota Mining & Mfg. Co., two companies are already considering the possibilities of using taped messages for such advertising.

• • •

Measure of misery caused by summer heat, the "discomfort index" will be announced by many U. S. weather stations this summer, on an experimental basis. The discomfort index, as worked out by Weather Bureau climatologists, is four-tenths of the sum of the dry and wet-bulb thermometer readings, plus 15. It is estimated that in the summer about 10 per cent of the population will be uncomfortable even before the index reaches 70; when it passes 75, more than half will be uncomfortable; and at 79 everybody will be uncomfortable, many feeling acutely miserable. Besides letting people know when they should be mopping their brows, the index will inform managers of commercial buildings when to turn on air conditioning and will enable utilities to estimate power requirements for it.

Replace your awkward, obsolete needle valves!

NOW— ON-OFF at 3000 PSI with new quarter-turn FLO·BALL plug valve

. . . priced no higher than needle valves!

Hydromatics Series 715 Spherical Plug Valve breaks through 150 PSI limitation of ordinary plug valves!

- **LOW TORQUE, EASY ACTION**... Quarter-turn operation, requiring only 4 lb-in torque at 3000 PSI.
- **MAXIMUM FLOW EFFICIENCY**... Straight-thru FLO·BALL design has more than twice the flow of needle valves.
- **POSITIVE ON-OFF INDICATION**... The large, arrow-shaped handle shows valve position at a glance.
- **ZERO LEAKAGE**... Mass Spectrometer tests with Helium prove zero leakage.
- **UNIVERSAL MOUNTING**... Can be panel, side, bottom or line mounted.
- **REMOVABLE FLANGES**... Replace damaged flanges in seconds—no need to scrap entire valve.
- **VERSATILE SERVICE**... Leak-proof control of air, vacuum, steam, water, fuels, oils, kerosene, alcohol and many other media.

PORT STYLES AND SIZES

NPT		AND10050	
Size	Part No.	Size	Part No.
1/8	715A1	1/4	715A2
1/4	715B1	3/8	715B2

NOTE — Other models are available for service with cryogenic and corrosive media. Also special designs for throttling flow control.

ALL STAINLESS STEEL CONSTRUCTION — COST NO MORE THAN OLD FASHIONED SCREW-TYPE VALVES!

NEW CATALOG!

WRITE, PHONE or TWX for Hydromatics' new catalog, describing the world's most complete line of precision valves for industrial and military applications.

HYDROMATICS, INC., 70 OKNER PARKWAY, LIVINGSTON, N. J.
Phone WYman 2-4900 • TWX Livingston NJ 120

Hydromatics, Inc.

Pasadena: 35 N. Arroyo Pkwy., RYan 1-7448 • Washington, D.C.: 1413 K St., N.W., STerling 3-3612 • Seattle: GLencourt 4-0577 • Indianapolis: 889 E. 82nd St., CLifford 1-5287

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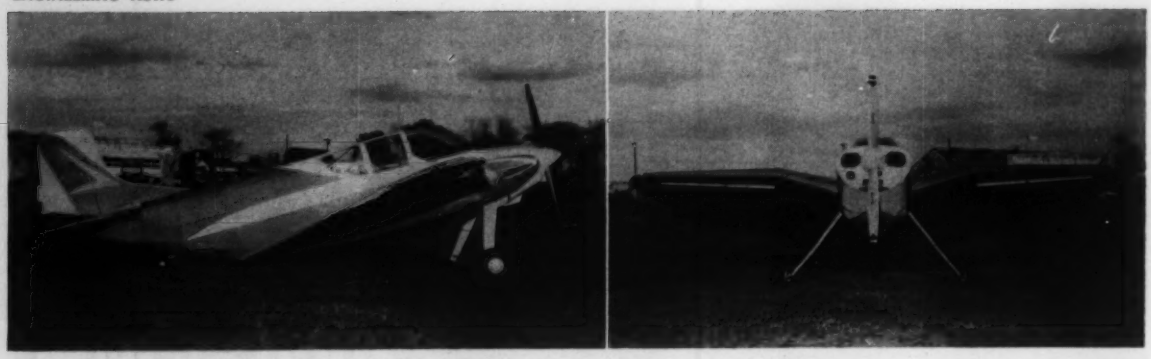


STOL Slows to 15 mph with Flaperons and BLC

Backyard "airports" aren't out of the question with the STOL Paraplane Commuter. Equipped with full-span flaps, flaperons, and natural boundary-layer control, Lanier Aircraft Corp.'s new single-place aircraft takes off and lands with a 60-ft run, clears a 50-ft obstacle in 165 ft. Grossing 1280 lb (500-lb useful load), the Paraplane has a 165-mph top speed, slow flies under power at 15 mph. Powerplant in the single-place model is a 150-hp Lycoming. A four-place model with comparable short-field performance tops out at 171 mph on 180 hp.

Design Show-Conference Comes To Philadelphia May 25-28

Exhibits and Conference Sessions Will Be in Convention Hall

NEW YORK—The Fourth Design Engineering Show and Conference, which has become one of the country's largest industrial expositions, returns to the scene of the first Design Show, held in Philadelphia in 1956. Exhibitors at the first show numbered about 200, and six papers were presented at the conference. This year over 400 companies will be represented, and 15 papers have been scheduled for presentation.

Exhibits will feature mechanical components, power - transmission equipment, electrical and electronic components, metals, nonmetallic materials, fasteners and adhesives, finishes and coatings, shapes and forms, hydraulic and pneumatic components, and various engineering equipment and services.

The show will be open from noon until 5:30 p.m. Conference sessions will take place in the mornings. The Monday and Thursday morning programs will deal with the philosophy of engineering design overseas and engineering organization, respectively. On Tuesday and Wednesday, concurrent sessions will be devoted to materials, power and control, and mechanical aspects of design. The complete conference program will appear in the next issue of MACHINE DESIGN.

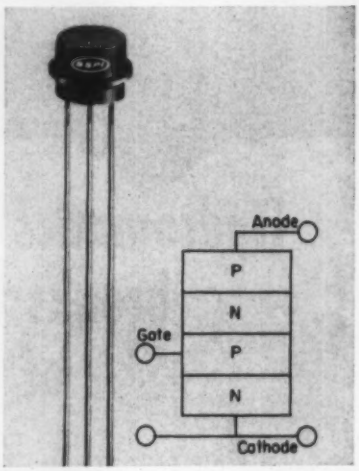
New Solid-State Switch Can Replace Relays, Tubes

Three-Junction Transistor Operates Like a Thyratron

SALEM, MASS.—The silicon PNPN controlled switch, a new semiconductor representing a significant state-of-the-art advance, permits high-gain, high-speed switching in the current range of 10 to 1000 ma. Typical current gains of 500 and power gains of 250,000 are possible at output peak current levels of 1000 ma. This compares to current gains of 50 and power gains of 2500 with today's silicon transistors. In addition, the new switch requires only an instantaneous input pulse to switch and stay on. Transistors require continuous input.

Developed by Solid State Products Inc., Salem, Mass., the PNPN switch is now in pilot-line production. Some of its expected applications: Magnetic-core switching, flip flops, logic circuitry, pulse generation and shaping, inverters, motor controls, regulated power supplies, and servo systems. The switch is particularly suited to ac static-switching and control circuits.

Within its ratings, the PNPN switch can replace mechanical switching devices such as relays and vibrators—with the advantages of reduced size and no moving parts. It can also be used to advantage in place of magnetic amplifiers, thyratrons, tubes, semiconductor diodes and rectifiers, and conventional transistors.



Addition of a third control element (the normal silicon transistor has two) gives the PNPN triode switch the characteristics of a gas thyratron. One variety of the new switch, the controlled rectifier, is already in service.

Physically, the PNPN switch is similar to a transistor, but instead of two interacting junctions, the new device has three. The resultant effect, electrically, is a device with properties similar to those of a gas thyratron. In the reverse direction, its characteristic is the same as the reverse characteristic of a conventional diode. In the forward direction, it will either conduct heavily (on condition) or block (off condition), depending on whether or not a gate current has been applied.

N/D CASE HISTORIES

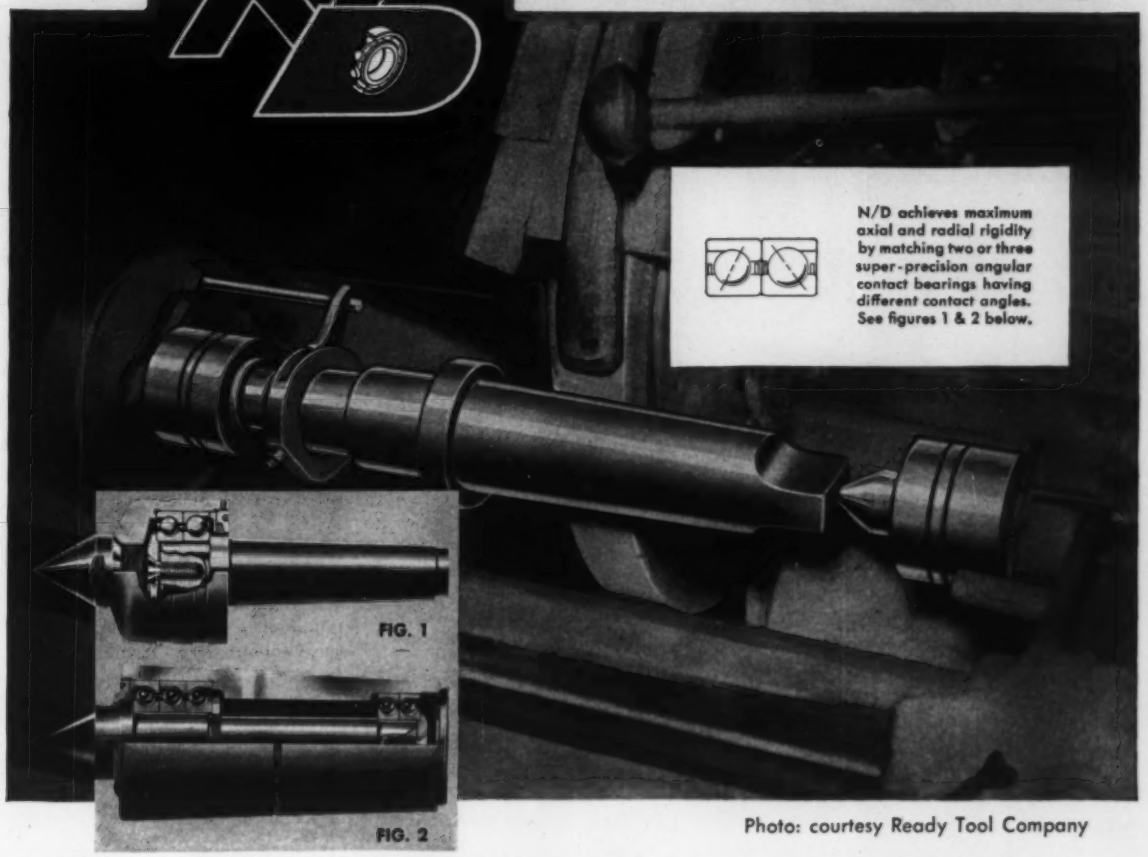

N/D achieves maximum axial and radial rigidity by matching two or three super-precision angular contact bearings having different contact angles. See figures 1 & 2 below.
FIG. 1
FIG. 2

Photo: courtesy Ready Tool Company

N/D Bearing Design Helps Live Center Maker Achieve Accuracy of .000050"!

CUSTOMER PROBLEM:

Live center maker requires bearing design that will help achieve . . . and maintain . . . live center accuracy of .000050", under combination radial and thrust loads.

SOLUTION:

After thorough evaluation of the problem, New Departure recommended N/D pre-loaded, duplex ball bearings. Extensive testing proved these super-precise ball bearings resisted combination radial and thrust loads with minimum deflection. The N/D ball bearings, with medium and high contact angles, are mounted duplex and positively clamped together to assure the optimum, pre-determined preload condition. As work expansion increases the thrust load, radial centering becomes more rigid and accuracy is precisely maintained . . . to less than .000050" total indicator run-out!

When you're working on new designs that call for high precision ball bearings, why not call on New Department? New Departure's consistent precision is your assurance of the ultimate in accuracy for your design. For more information, call the New Departure Sales Engineer in your area or write Dept. Q-4.

Replacement ball bearings available through United Motors System and its Independent Bearing Distributors

NEW DEPARTURE

DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

NOTHING ROLLS LIKE A BALL

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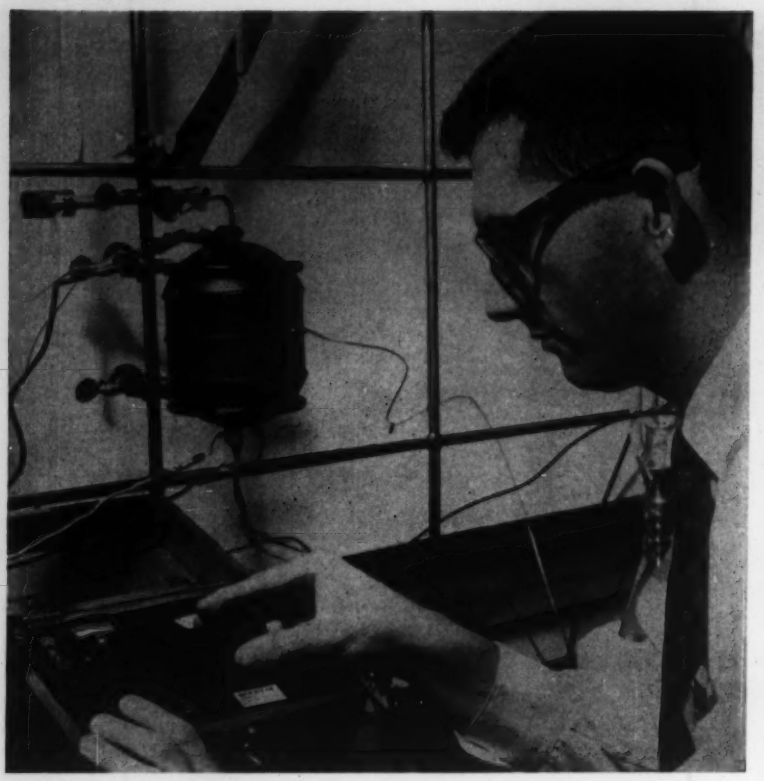
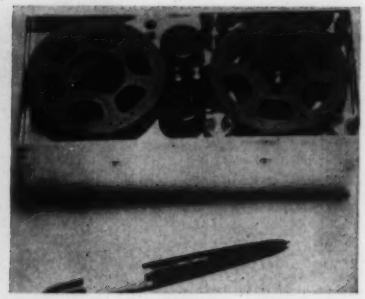
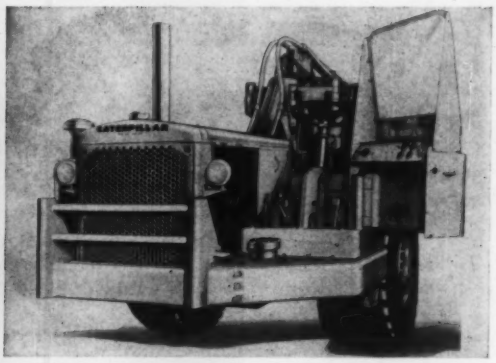




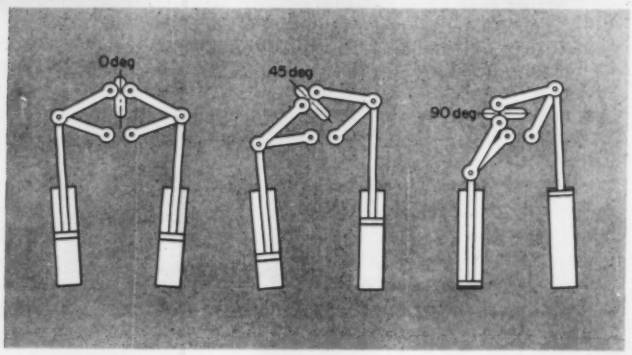
Best of the Smallest in '58

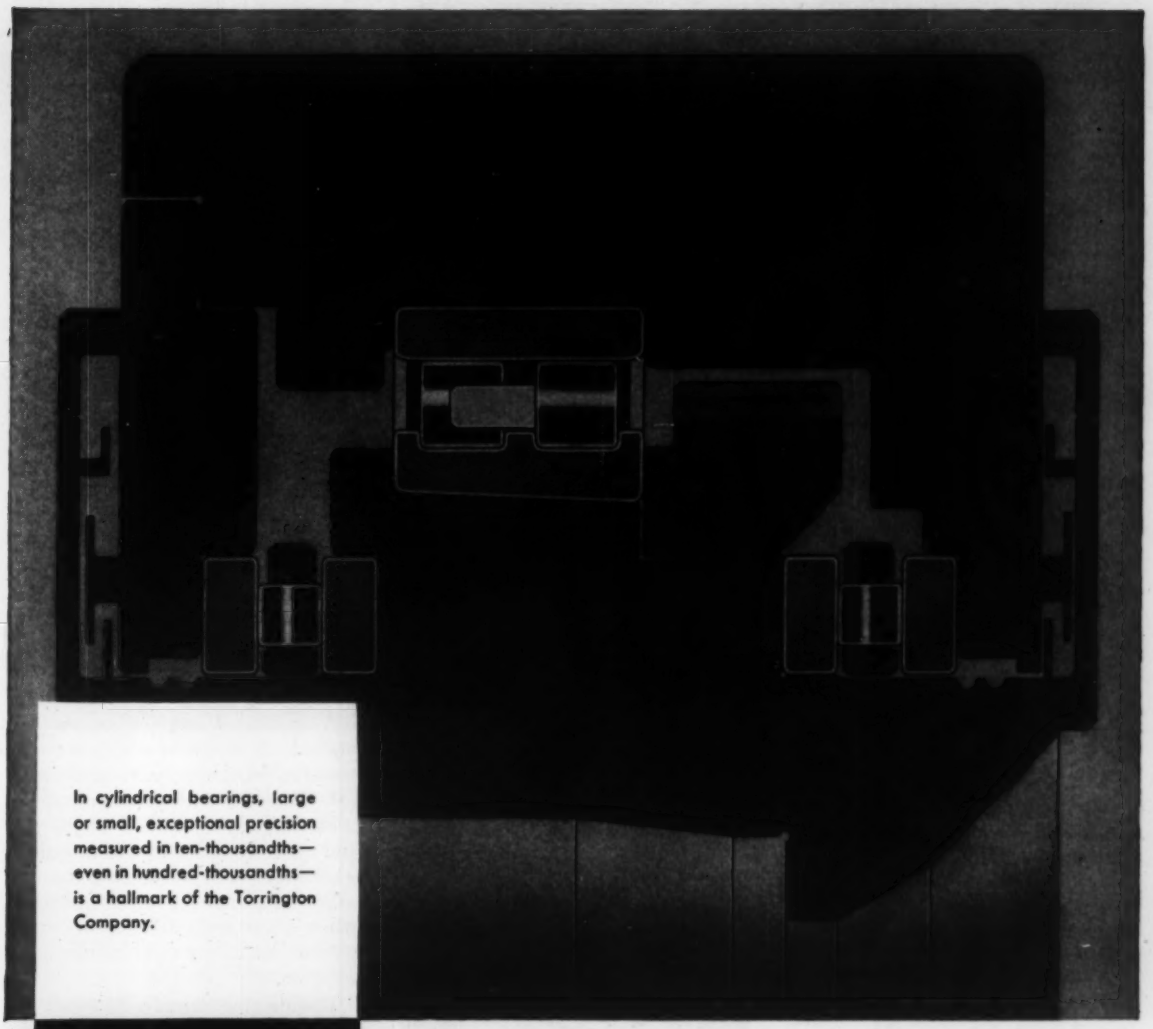
Snap III, the 5-lb, 100-w atomic generator developed by Martin Co. is winner of the 1958 Miniaturization Award. Recognized as a major breakthrough in electrical power sources, the "radioisotopic battery" is capable of producing power during its lifetime equivalent to the output of 1500 lb of dry-cell batteries. The miniature tape recorder, above, developed by Stanford University student Keith O. Johnson, is one of ten runners-up for the '58 award. The four-channel recorder weighs 3 lb and will operate 90 hr from its self-contained batteries. The annual Miniaturization Award was established in 1957 by Miniature Precision Bearings Corp., Keene, N.H.

High-Speed Two Wheeler Features Fast Maintenance

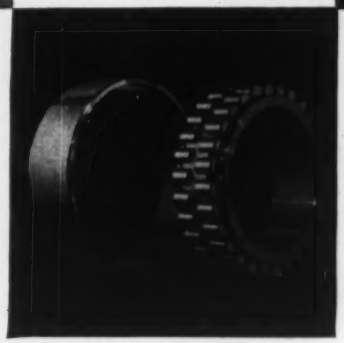


Travel speed of 30.2 mph puts Caterpillar's new two-wheel tractor in the road-racing class of road builders. Besides speed, the new tractor also incorporates innovations in maintainability and steering. Swing-away dash, above right, permits ready access to the entire left side of the engine without disassembly of any major dash component. A new 90-deg, two-cylinder steering system, right, eliminates an objectional feature common to previous two-cylinder mechanisms—reversal of piston action at a point half way through the steering arc. In the new Cat system, pistons move in one direction only, eliminating the possible loss of control during high-speed turns.





In cylindrical bearings, large or small, exceptional precision measured in ten-thousandths—even in hundred-thousandths—is a hallmark of the Torrington Company.



Visit Torrington
Design Engineering Show
Philadelphia
May 25-28

Turns true within three "tenths"!

To the engineer, that means these large Torrington Cylindrical Roller Bearings have a total radial runout of only .0003"—three ten-thousandths of an inch! To anyone, that means ultra-precision.

These are spindle bearings custom-built for Gisholt Machine Company's center drive lathe. The tapered bore, two-row radial roller bearing is 44.2500" OD, capacity 189,000 pounds at 100 rpm. Face runout is held to .0005". Each of two cylindrical thrust bearings used is 38.4700" OD, capacity 105,000 pounds at 100 rpm. Diameter of rollers in any one bearing is held within one-half "tenth"—.00005".

This close approach to perfection is made possible by specialized equipment and superior workmanship, which go into the manufacture of every Torrington Bearing, large or small. Of course, not every application requires such ultra-precision. But each bearing requirement is given the extra measure of care that makes Torrington quality a byword in industry. **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**

TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST

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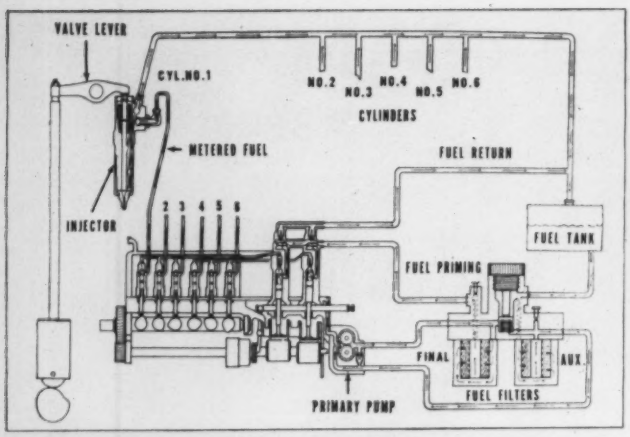
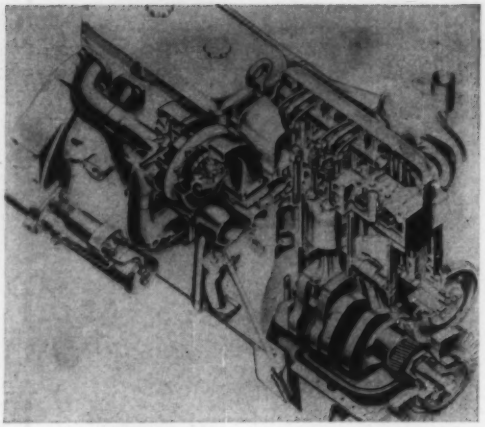




Double Metering Smooths Diesel Power

Individual injectors mounted above each cylinder double check the metering of fuel from a standard twin-plunger pump in International Harvester's new 385-hp turbocharged diesel. Fuel that leaks past each injector plunger is returned to the main line through a bypass system. Offset counterbores on intake valves swirl incoming air and thoroughly mix it with the fuel. The result is exceptionally even power from all six cylinders. A naturally aspirated version of the new engine, rated at 250 hp at 2100 rpm, has minor differences in valve and injection timing.

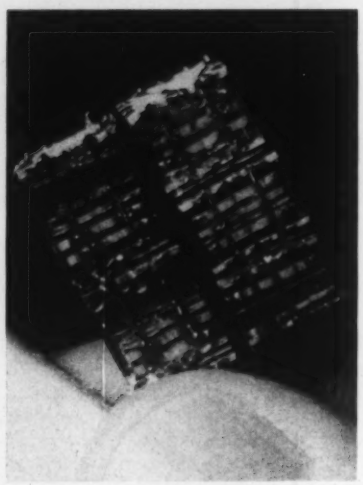
Tiny Electronic Building Blocks Promise Miniaturization Breakthrough

Army's Micro-Modules Ready for Production

NEW YORK—Success of the Army's electronic miniaturization program promises a tenfold reduction in the size and weight of many vital military devices. The vast range of jobs done by transistors, resistors, and other electronic parts is now being compressed into tiny micro-modules —circuit building blocks measuring only 1/3 in. on each side.

Since the program was launched about a year ago, tests carried out by the prime contractor, RCA, and U. S. Army Signal Corps show the tiny cubes to be highly dependable and long-lived. They use little power, deliver high performance, and greatly simplify repairs. The units are extremely rugged due to their simplicity and monolithic shape. RCA engineers also report that micro-modules are ideal for economical automated production, inspection, handling, shipping, and storage.

The smallest units of a micro-module are tiny flakes of conducting, semiconducting, or insulating materials, 0.01-in. thick and 0.33 in. square. Added materials and controlled processing of the wafers turn them into micro-elements with the ability to do the job of specific components such as resistors, transistors, capacitors, diodes, inductors, and crystals. Some of the micro-elements do the work of several conventional parts, since combinations can be on one element.



Circuitry for a complete radio is contained in a stack of micro-modules having the approximate overall dimensions of a sugar cube.

A group of micro-elements are stacked up, interconnected, and encased to form the micro-module itself. These operate as complete circuits, such as amplifiers, oscillators, and other complex electronic subassemblies. While most modules are cubes, they can be varied in length when necessary. Modules are compatible with present conventional component structures.

Engineering samples of types developed under the present RCA contract will be made available in the second half of this year to other military contractors for development of prototype equipment. Later phases of the program include building prototype production machinery. This would set the stage for numerous contractors to work toward volume output of modules and design them into many kinds of equipment.

Although micro-modules are being developed primarily for defense requirements, they are destined to change the appearance of many commercial products, possibly within 3 years. Flat, wall-type television sets are a definite possibility—circuitry and components would be mounted in the rim of the picture frame. Lilliputian radios and dictation machines are also a possibility. Button-size batteries, now on the market, would power the devices.

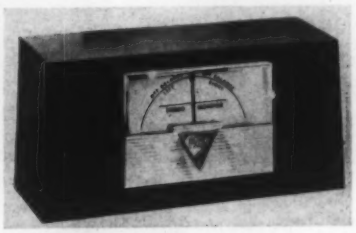
First Aluminum Submarine Will Set Diving Records

SAN ANTONIO—A new generation of superlative submarines, born in Texas, may appear in the next few years. Under a program sponsored by Reynolds Metals Co., scientists at the Southwest Research Institute are working on the preliminary design of a submarine capable of diving more than 15,000 ft under the sea. This is about 15 times the capability of present submarines. The remarkable craft, called the *Aluminaut*, will have an all-aluminum hull.

It will be about 48 ft long, with a 30-ft cylindrical pressure hull fabricated from 6-in. aluminum plate. Its 7-ft inside diameter will house a pilot and two scientific observers, plus a 3400-lb instrument payload.

The battery-powered main propulsion system will be mounted in an independent stern capsule filled with oil to equalize pressure. In addition to the stern propeller, the boat will also have a vertical propeller to permit hovering while making observations and to aid in ascent or descent. Three built-in ballast systems have been provided: 1. shot tanks amidship, 2. submergence water tanks in the keel, and 3. solid-steel keel ballast which is fail-safe detachable for emergency ascent.

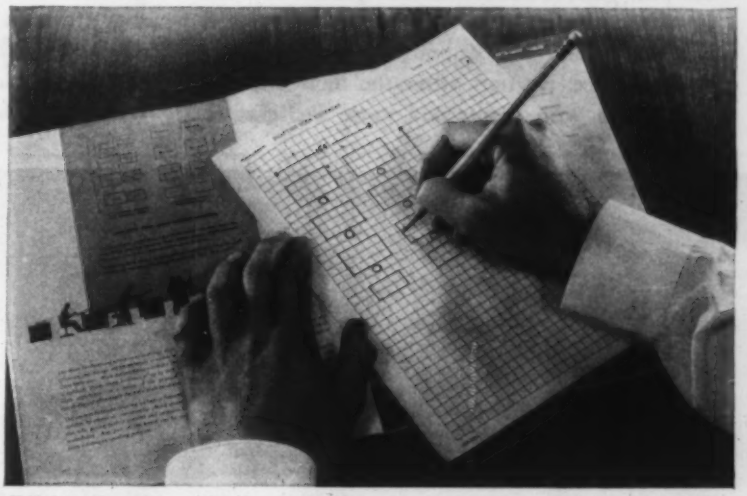
The ship will be bolted together, and seams will be caulked and joined with a special adhesive which is now used in bonding the skins of some airplanes.



New Aid for Stereo Buffs

Stereo speakers are balanced visually with this new differential meter developed by Park Products Co., Cleveland. A null pointer in the device takes the guesswork out of setting speakers for equal loudness. It handles 30 watts on either side and permits channels to be balanced with either stereo or monaural records. The meter is designed for both home use and OEM.

DRAFTING TRENDS



Efficient drawing and reference table arrangements are most important. The new Post/Hamilton Catalog serves as an excellent guide to more up-to-date drafting room layouts. See special offer below.

Modern space savers are important time savers

Space saving and more efficient use of manpower are part of a never-ending trend. In drafting rooms, modern space saving techniques are exemplified in Post/Hamilton Auto-Shift Tables.

A 30% saving in floor area is not unusual with proper planning when replacing older tables with Auto-Shifts. And it can be done without crowding. The Auto-Shift is designed for the man-on-the-board. There is ample reference and storage space and the slope of the board is easily controlled through a 0° to 90° range, or the board raised and lowered by fingertip action. This boils down to eliminating unnecessary reaching, cutting clutter, ending back fatigue. The Auto-Shift provides such "extras" as stylized leveling legs, full width foot rest, a triple electrical outlet, integral roll tracing storage bin, foot pedal for vertical board control.

Another space saver is the Post/Hamilton "L" Contour Unit. This combination drawing-reference unit affords complete flexibility of board movement with a choice of either a right or left hand reference area.

Space saving filing systems

Efficiency in filing can be a very important work saver, too. Post/Hamilton vertical filing units provide for maximum protection, ease of classification, and efficient use of all storage areas. Specialized cabinets allow for storage of tracings, prints, engineering records, and roll tracings all in one stack of vertical files. This is the UnitSystem, a file control which can be custom-tailored to your needs.

Send for complete POST/Hamilton Catalog

Write for the 1959 Post/Hamilton Drafting Room Equipment Catalog today. It pictures the newest drawing tables and filing systems on the market, and will suggest many new approaches to your drafting room efficiency. *Write to Frederick Post Company, 3652 N. Avondale Avenue, Chicago 18, Illinois.*

POST

SENSITIZED PAPERS & CLOTHS • TRACING & DRAWING MEDIUMS • DRAWING INSTRUMENTS & SLIDE RULES
ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

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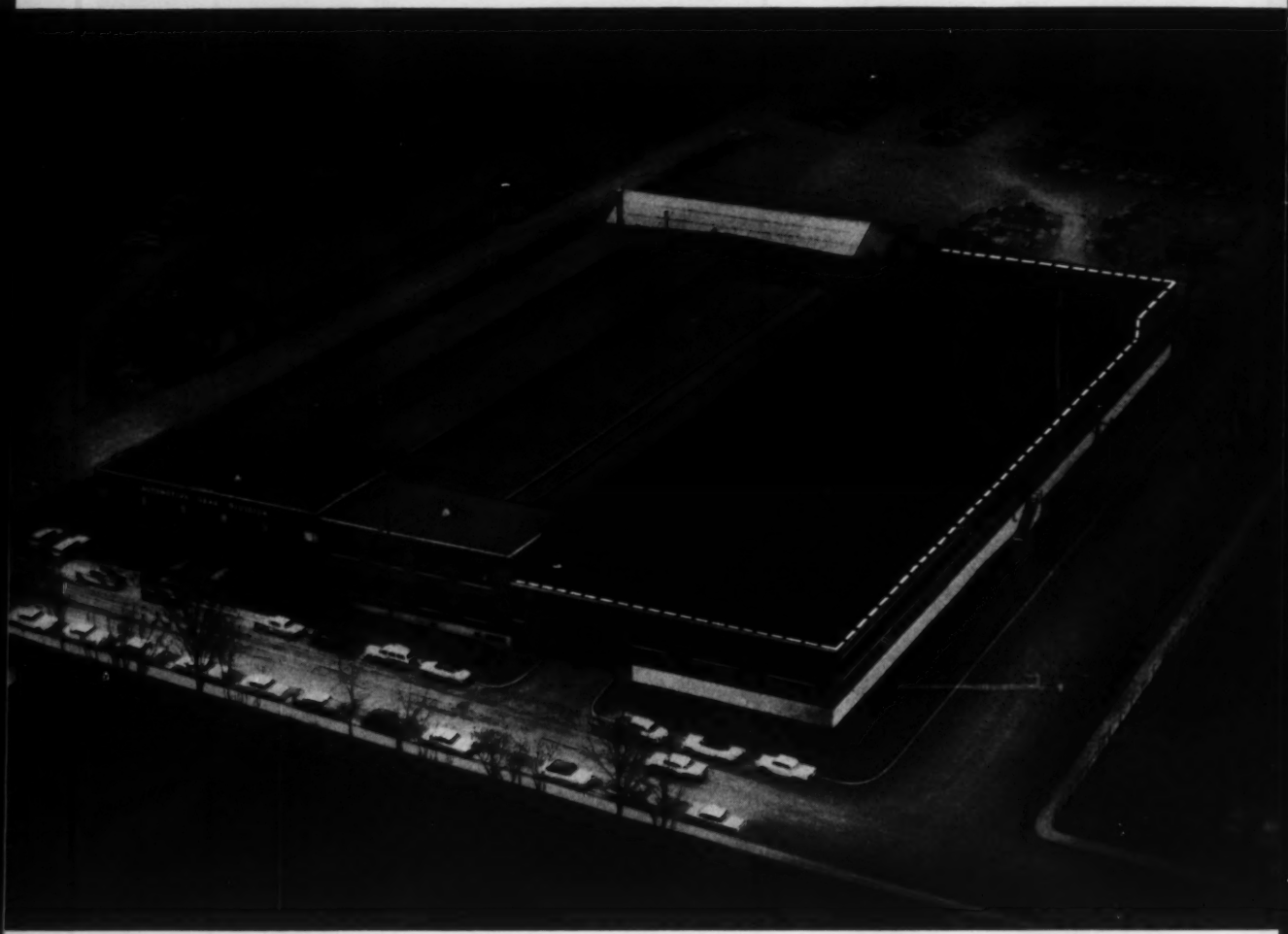
THIS MUCH MORE in '59

Expansion was not the order of the day during the past year, but it was in this period that the growing sales of "Double Diamonds" required the addition of 60% more manufacturing space. Hence, we now enter the more promising future with better and more facilities to serve as your "gear department" or to fill your gear orders with "Double Diamond" Gears that are built *to produce low installed cost... to serve economically and dependably on the job for which you buy them... and to do credit to your product and your reputation.*



May we send you this catalog of the gear types in which we specialize: helical gears, flywheel starter gears, straight bevel gears, straight spur gears, angular bevel gears, hypoid bevel gears, gear assemblies, zerol* bevel gears, spiral bevel gears, and spline shafts?

*Reg. U. S. Pat. Off.

EATON

AUTOMOTIVE GEAR DIVISION
MANUFACTURING COMPANY
RICHMOND, INDIANA

GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

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Reader Information Service

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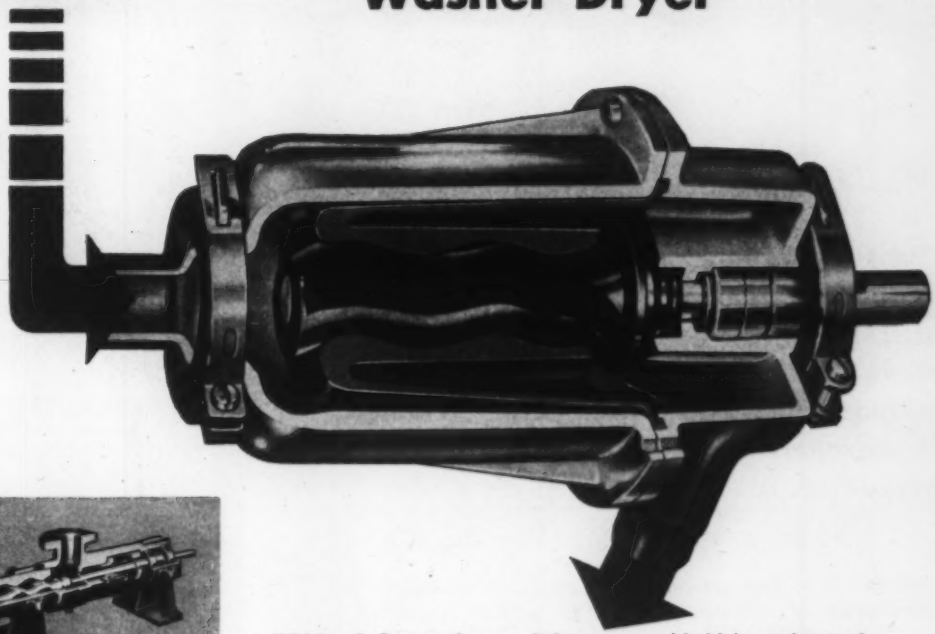
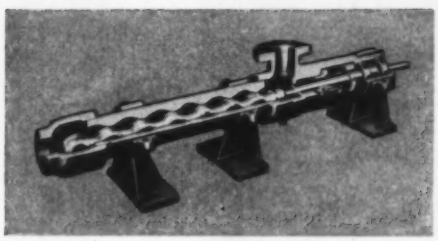
(Pebbles and all) for

RCA WHIRLPOOL

Washer-Dryer





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Whirlpool Corporation needed a pump with high suction and positive displacement for its automatic combination Washer-Dryer. Though sparing of water during wash-and-7-rinse cycle, each RCA Whirlpool combination circulates oceans during its long life. A Moyno Pump provides the continuous, uniform flow, 1 to 15 gal./min., free from air locking. Most important, even relatively large particles—sand, pebbles, children's pocket loot—can't stop a Moyno Pump!

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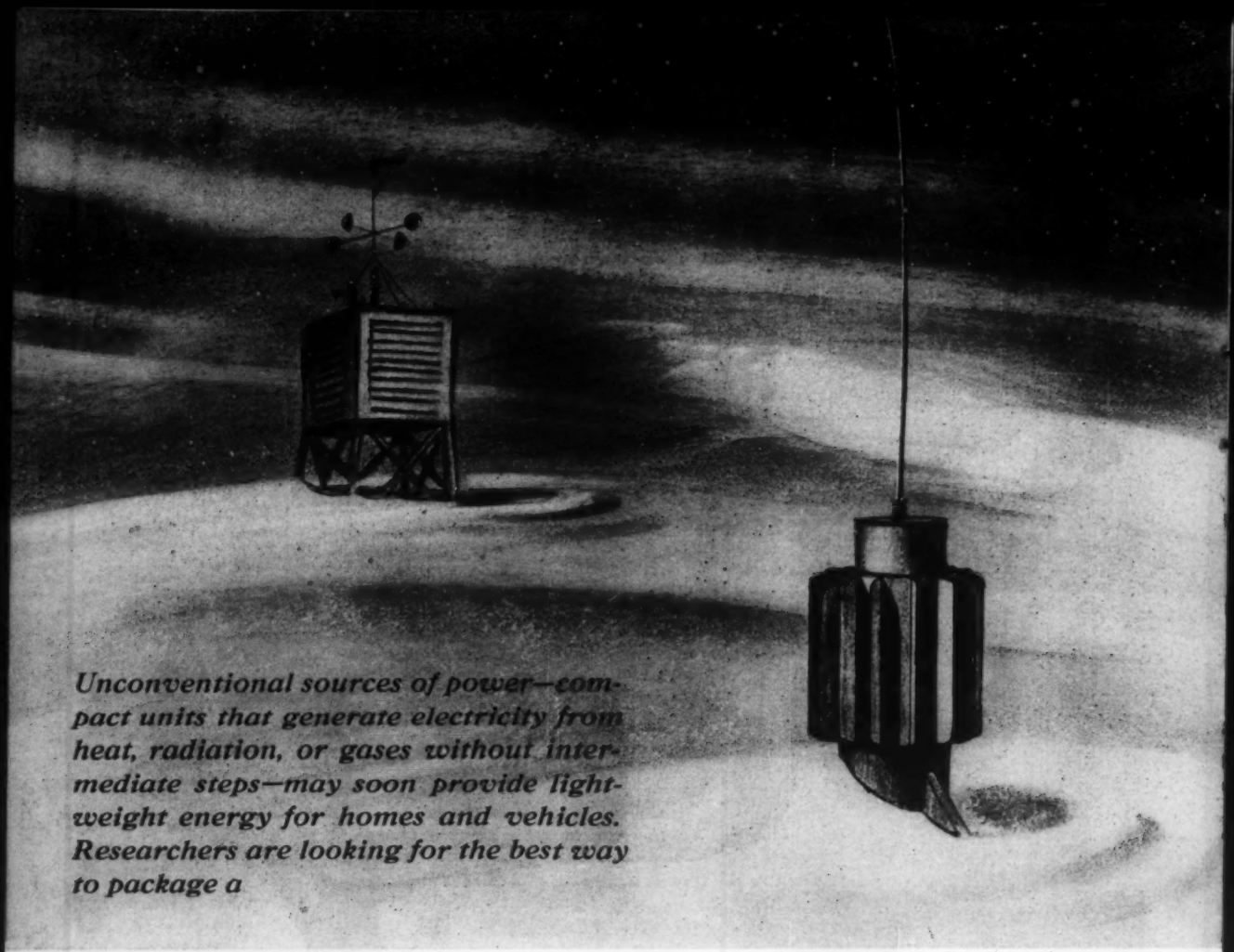


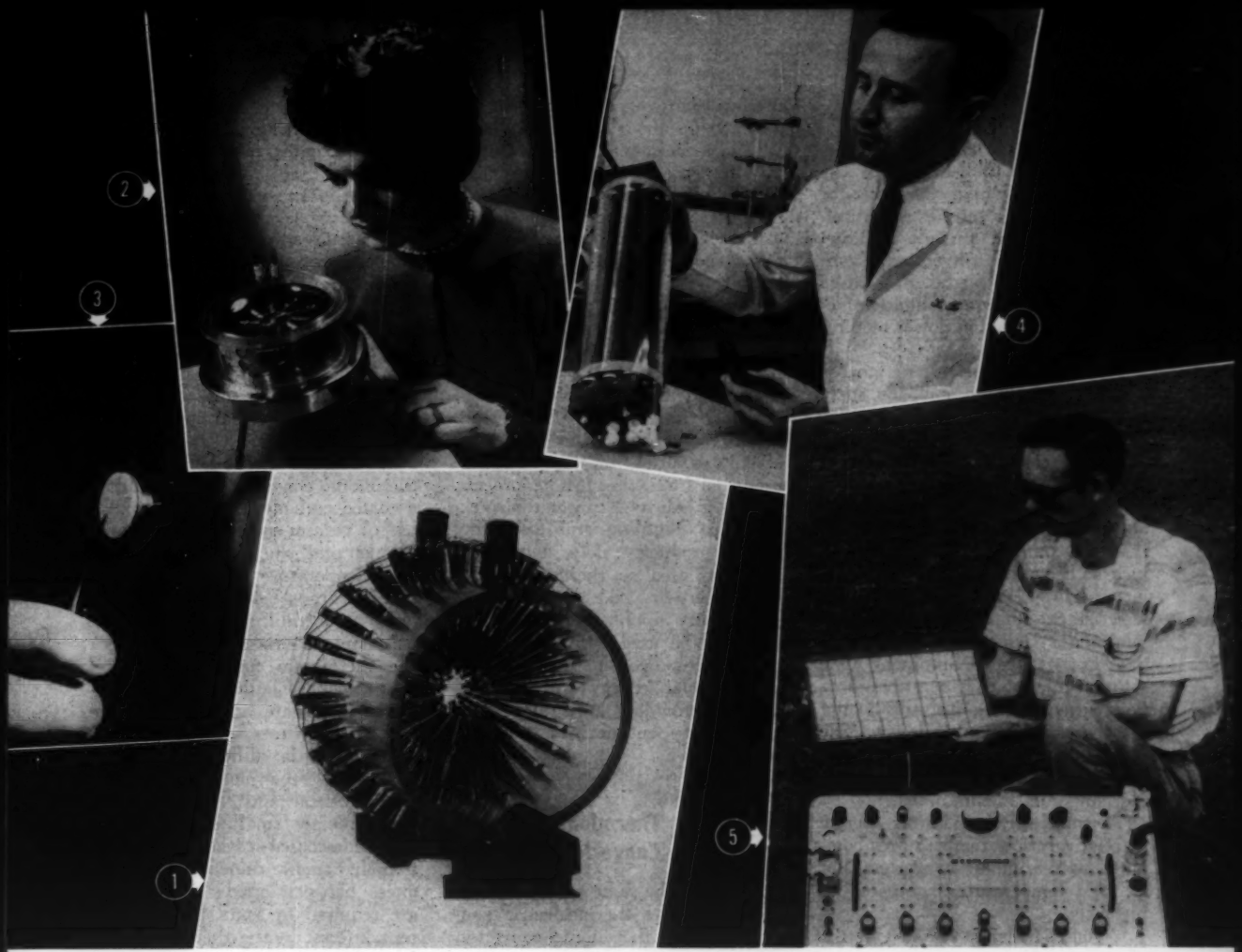
Unconventional sources of power—compact units that generate electricity from heat, radiation, or gases without intermediate steps—may soon provide lightweight energy for homes and vehicles. Researchers are looking for the best way to package a

powerhouse in a capsule

SCIENTISTS around the world are searching for compact new sources of electric power. Advances in thermoelectric and thermionic converters, gaseous and solid-state fuel cells, and direct-radiation devices are reported regularly. Such unconventional power sources promise to answer growing needs in space, in domestic use, and in underdeveloped areas throughout the world.

Unconventional sources are a must wherever conditions rule out conventional generators or chemical batteries. Sources for satellites and space vehicles, for example, must have long life, light weight, and consume only little fuel. If possible, they must permit fuel recycling, whereby the end product can be regenerated—by solar or nuclear energy—and fed back into the system. The elimination of waste products in a space system is of first importance.

In domestic use, it is entirely possible that efficient packaged sources can be developed for small installations. Present-day transmission and distribution costs represent a large part of the cost of electric power in the home. An electric power source with the reliability of a modern refrigerator would become a practical device if it could serve the needs of a single householder. The potential cost of such a system appears, on rough calculation, to be practical if fuels such as natural

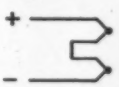


Generation of power without moving parts is the feature common to these unconventional sources: **1.** Thermoelectric generator, Horizons Inc. **2.** SNAP III thermoelectric source, Martin Co. **3.** Thermionic converter, General Electric Co. **4.** Fuel cell, National Carbon Co. **5.** Solar cell, Texas Instruments Inc.

By EDWARD F. MAYER
Department Head, Physics
Horizons Inc.
Cleveland, Ohio

gas can be employed as the fundamental source of power.

In most underdeveloped countries, it is unprofitable to install advanced industrial complexes, distribution systems, and power-generation equipment at this stage in their growth. But small new sources of electricity may be expected to power radios and lighting, and to energize small motors for pumping and mechanical power. Such devices will produce a tremendous impact on underdeveloped communities and expedite the need for larger power sources.



Thermoelectric Sources

The thermoelectric (heat-to-electricity) principle has long been applied for instrumentation purposes in the thermocouple. Latest efforts have been directed at applying thermoelectricity to furnish useful power. Recently announced devices include a thermoelectric generator developed by Horizons Inc. for the Rome Air Development Center, and Snap-III, a thermoelectric generator developed jointly by the Martin Co. and Minnesota Mining and Manufacturing Co. The Russians have reportedly done much work with thermoelectric devices and are now using kerosene heat sources.

Current interest in the thermo-

electric generator runs high, especially for application in various satellite projects where the ratio of weight to power output is critical. Here, the large amounts of fuel needed to power conventional generators, or the weight of a large chemical battery are prohibitive factors for long-duration power requirements.

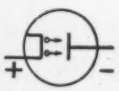
The thermoelectric generator is a solid-state device and, as such, is not subject to some of the difficulties encountered by other unconventional sources. A hydrogen-oxygen fuel cell system in a space vehicle, for example, would probably have to recycle its fuel. Water, the cell's combustion product, would have to be collected and electrolyzed for recycling. But this poses a problem, since simple collection and pumping systems are not practical in a gravity-free environment. One solution may be to generate an artificial gravity field, but this would greatly complicate the design. The use of a solid-state device would sidestep the problem entirely since recycling fuel is eliminated.

Thermoelectric generators operate at relatively low temperatures compared to thermionic converters, but at high temperatures compared to fuel cells.

Highest efficiency attained by the thermoelectric generator so far appears to be about 5 or 6 per cent. Within a reasonable period of time, this may be raised to 10 per cent. Although ultimate efficiencies as high as 15 or 30 per cent have been called feasible, knowledge of the thermoelectric process will have to advance considerably before such high values can be realized.

Compact thermal sources—either nuclear or thermal—for thermoelectric generators are now available. Encapsulated radioisotopes will probably find widest use because they generate heat and are available in a variety of types as waste products from the fission process. There is always considerable expense in handling and discarding fission products safely, but when they are used as thermal sources, this cost is defrayed.

In many applications, solar energy can be used with thermoelectric devices, even to the point of storing solar energy in the form of heat, providing a relatively uniform energy output from the generator.



Thermionic Converters

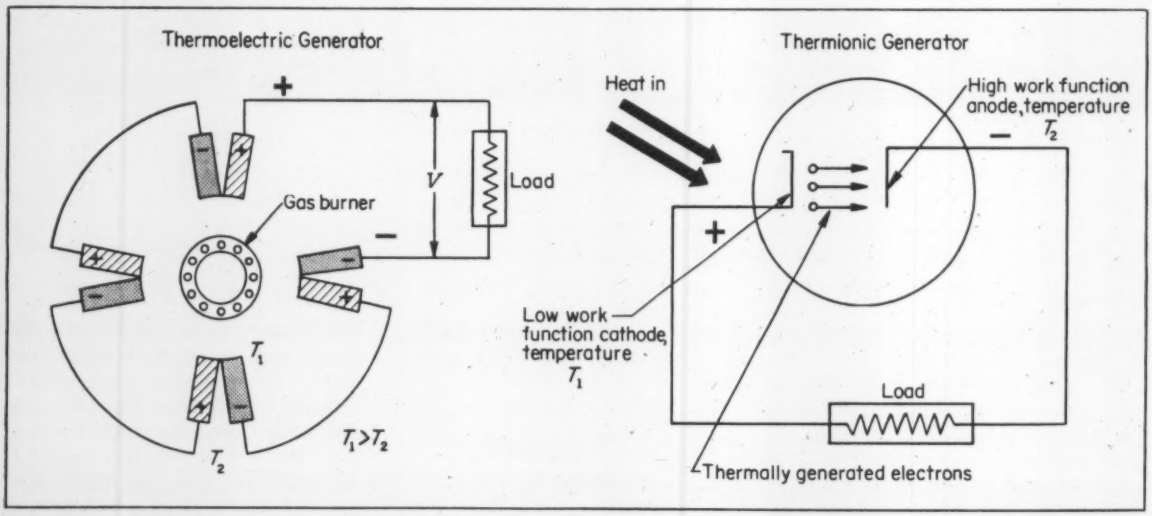
In much the same state of development as the thermoelectric generator is the thermionic converter. Only recently has the system been developed far enough to show promise of becoming a useful source of power.

There is one basic difference between thermoelectric generators and thermionic converters: Operating temperatures for thermionic converters are, on the average, higher than for present-day thermoelectric generators. On the other hand, much effort is being directed at raising operating temperatures of thermoelectric devices because of the increased efficiency that could be obtained.

Basically there are three types of thermionic converters: One employs a coated cathode; the second makes use of cesium vapor inside the envelope; and the third operates at high temperature and high vacuum, with electrons being emitted directly from a metallic surface.

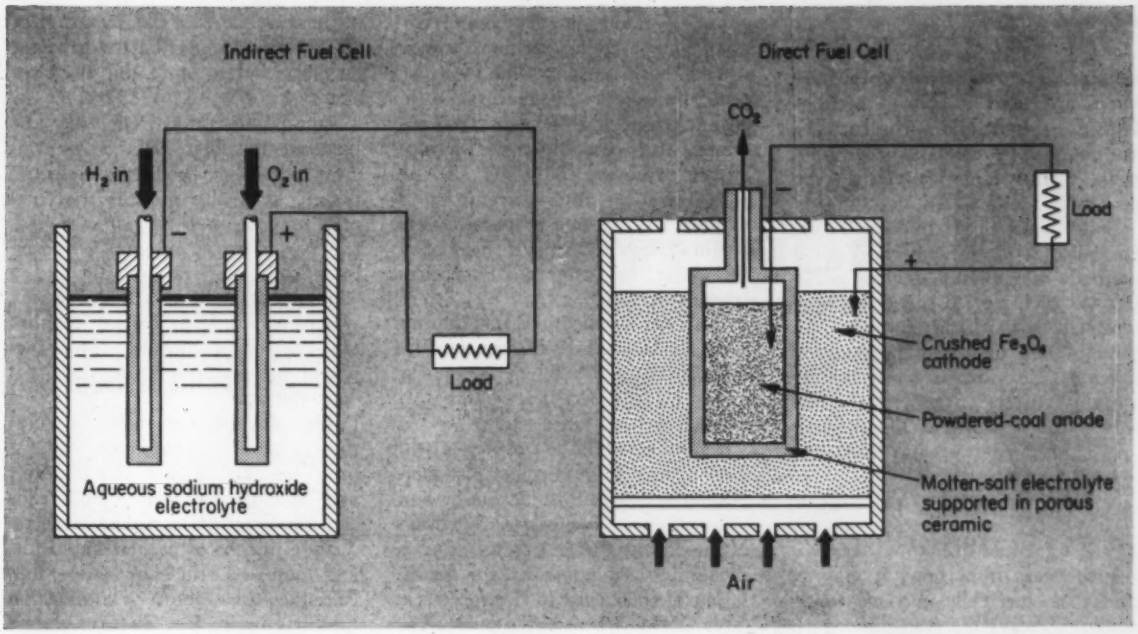
Maximum efficiency predicted for the thermionic converter is about 30 per cent. Claims for efficiencies obtained to date have ranged from 5 to 10 per cent.

Some of the difficulties met in developing thermionic converters are that heat must be enclosed in an extremely small space to heat an oxide-coated cathode, and extremely small dimensional tolerances between anode and cathode are required in some designs. Current interest in the thermionic con-



HEAT-TO-ELECTRICITY power sources operate either as thermoelectric or thermionic devices. The thermoelectric generator (left), like the familiar thermocouple, takes advantage of the Seebeck effect. Heat applied to a junction of dissimilar metals generates an emf when a second junction, formed by external wiring, is held at a lower temperature.

In the thermionic source (right), thermally agitated electrons are "boiled" out of a heated cathode. Velocity imparted to the electrons carries them to the anode, charging the anode negatively, the cathode positively.



POWER FROM FUEL CELLS is generated either through indirect or direct processes. The indirect cell (left) operates on an input of gaseous hydrogen and oxygen. Diffusing through the porous electrode wall, the hydrogen ionizes and gives electrons to the electrode when entering the electrolyte. Similarly, at the anode, oxygen ions pick up electrons when entering the electrolyte.

Power generation in the direct fuel cell (right) results from combination of carbon and oxygen. Elemental carbon in the powdered coal combines with positive oxygen ions in the electrolyte and simultaneously releases electrons to the anode. Oxygen ions in the electrolyte are replaced indirectly by reaction of the input air and the crushed Fe_3O_4 cathode. Elements consumed are powdered coal (carbon) and oxygen in the air supply. A working cell would include provisions for replenishing the coal.

verter is still primarily in the laboratories, and this particular device is probably the furthest from practical application.

Fuel Cells

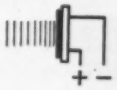
The fuel cell is a device for converting energy of a chemical reaction directly into electricity. Attractiveness of the fuel cell lies primarily in the extremely high efficiencies that can be obtained. In the combination of hydrogen and oxygen in a fuel cell, for example, the energy of combustion is converted almost directly into electrical energy, and efficiencies can run 75 per cent and even higher. Potentially, this is a system for obtaining the optimum amount of electricity out of a given chemical reaction.

A number of fuel-cell variations have been proposed and worked on, both gaseous and solid-state. Fuel pairs have ranged from coal and air to hydrogen and oxygen. The only practical cell at this time is the hydrogen-oxygen type. However, a great deal of work is being done on many of the gaseous cells with the aim of employing such inexpensive fuels as natural gas.

The fuel cell differs from the other sources of power in that it derives its electric energy from the direct chemical combustion of two materials. Fuel cells fall into two classifications, direct and indirect. In the direct cell, natural fuels such as coal, petroleum, and gasoline are fed into the cell and combined with oxygen to produce electricity. In the indirect cell, natural fuels are caused to react or to be partially combusted so as to produce a fuel more compatible for use in a fuel cell; e.g., hydrogen or carbon monoxide.

Much work has been done to date on the direct combination of fossil fuels in fuel cells, but no practical solution appears to be in sight. Indirect methods may have to be employed. With more research, dissociation of water, either by nuclear or thermal methods, may provide a fuel for use in fuel cells.

Current interest in fuel cells is centered largely in the development of portable sources of electrical energy for use in space and other applications.



Direct-Radiation Sources

Direct-radiation sources — both solar cells and photocells — have been extremely popular, and a large number of practical applications have been developed. Bell Telephone Laboratories has led in this field with its silicon solar converters. These have theoretical efficiencies in excess of 15 per cent; present efficiencies of most cells range from 6 to 8 per cent.

The solar cell has probably been more widely used than any other unconventional source of electric power. Wherever there is sunlight or visible radiation, direct-radiation devices show promise for such service as charging batteries in remote installations.

The Bell Telephone Co., for example, has experimented on relay

stations in rural areas, where batteries are used as power sources. During daylight hours, the batteries are charged by banks of solar cells, thus storing the converted sun power.

Solar cells and photocells are basically semiconductors. Various methods of applying nuclear radiation to such devices have been attempted with little success. Although such units can be made to operate, the nuclear radiation invariably causes deterioration and early failure of the active surface.

What's the Timetable?

Five years from now, it may be predicted, fuel cells may efficiently employ gaseous materials. Here lies the possibility for making electric power available on a fairly economical basis for remote areas.

The thermoelectric converter probably offers the most promise within the next five years. For example, it is possible that thermoelectric recovery of some of the waste heat in internal-combustion engines will become practical. Some of this presently wasted heat may be utilized to power auxiliary electrical equipment.

Practical applications of thermionic converters, depending on the rate of their development, appear to be at least five years and possibly even ten years away.

The direct-radiation principle will find continued application in generating power from solar energy and may become practical to the point of supplying the power needs of a moderate-sized house by the installation of solar cells in the roof area. This, however, would not be economically profitable unless the price of these cells can be considerably reduced. Here again, batteries would be employed to store the electrical energy.

Automobiles may one day be powered by solar cells or by nuclear sources producing electric power. It is also possible that fuel cells may be used to generate electric power for locomotion purposes. Such cells may be fed air and a combustant, such as a hydrocarbon, which would form carbon monoxide or carbon dioxide. This fuel would be available from the local "gas station."

This development offers a solution to some of automobile exhaust problems that plagued city planners and officials for years. Fuel cells can be designed to produce carbon dioxide instead of carbon monoxide, and increased efficiency will actually reduce the amount of combustion products with less energy wasted in the form of heat.

Progress in Plastics

Corrosives have little effect . . .
on a new high-temperature (400 F) elastomer developed by Minnesota Mining and Mfg. Co. Called Fluorel, the new synthetic resists powerful oxidants such as 90 per cent hydrogen peroxide, and red fuming nitric acid. It can also be used with petroleum-base lubricants, hydraulic fluids, JP-type aromatic and Hi Cal fuels. The material can be milled and cut, compression molded, and has been extruded successfully in a standard rubber tuber. Bonding to most metals is possible with a silicone-base adhesive. Expected uses include aircraft and missile fuel cells, fire walls, air ducts, fuel and hydraulic hose, and seals.

Synthetic natural rubber . . .
or polyisoprene, is being produced commercially for the first time—the result of a cost-cutting production process developed by Shell Oil Co. Known as "the man-made duplicate of tree-grown rubber," polyisoprene has all the favorable characteristics of the real thing, plus a higher degree of uniformity. It can also be made in any plasticity required, another advantage over natural rubber. First application will be in truck tires, where polyisoprene's characteristic low heat build-up makes it superior to conventional synthetics. For the same reason, it will soon find wide usage in a variety of mechanical rubber components used in flexing and twisting operations.

Stretching it a bit . . .
35 per cent, in fact, has no effect on vinyl-to-steel bonds when a tough new adhesive developed by B. F. Goodrich Co. is used as the bonding agent. The new cement, called A-79-B, permits steel to be vinyl coated, embossed, and then deep drawn without destroying the adhesion or damaging the vinyl coating. Evaluation tests have included boiling a vinyl-steel bond in water for 30 min, exposure to 200 F dry heat for 170 hr, and humid storage (100 per cent relative humidity) at 160 F for 1000 hr. Expected uses are in the automobile industry for door panels, dash-boards, and trim—and in the appliance industry for stove, washer, and dryer cabinets.

Kept in solution . . .
a new rubbery material, called Estane VC, is deposited in film form; has a tensile strength of 7000 to 8000 psi. The unique plastic can be redissolved in the solvent and redeposited with equal properties. It resists oil and ozone and, unlike rubber, works without vulcanizing. Developed by B. F. Goodrich Co., the new material has 550 per cent extensibility and high elasticity. First commercial application is expected to be wire and cable jacketing. Other potential uses: Fuel hose, small-bore tubing, belting, and valve diaphragms.

High-temperature hose . . .
made of Viton and Dacron, withstands 600 F for short periods of time; will last indefinitely at 350 F. It also resists chemical attack by a number of solvents, including concentrated acids and bases, and can be used with a wide range of jet fuels and petroleum-base lubricants. Developed by H. K. Porter Co., using Du Pont plastics, hose is covered with Dacron, providing 600-psi burst strength.

Heat-shrinkable tubing . . .
provides a new method of aplying tight insulation to conduit, coils, transformer leads, and numerous other electrical components. The plastic tubing is preexpanded during manufacture and quickly shrinks to its normal dimension when exposed to 300 F for more than 4 min. Developed by Minnesota Mining and Mfg. Co, it has a dielectric strength of 1000 v (0.016 wall thickness), tensile strength of 3200 psi, ultimate elongation of 300 per cent, and a cold brittle point of −20 C.

Moon Landing Runs Poor Fourth In Public's Choice of Research

Sputnik Hysteria Lessens with U. S. Scientific Achievements

ANN ARBOR, MICH.—If money were available for only one of four scientific projects, the American public would prefer to spend it as follows: A new program for medical research, 54 per cent; new approaches to juvenile delinquency, 32 per cent; basic research in sciences such as chemistry and physics, 7 per cent; putting the first man on the moon, 3 per cent.

Findings are based on a random sample of 1500 adults, interviewed by the University of Michigan Survey Research Center for the National Association of Science Writers and New York University under a grant from the Rockefeller Foundation.

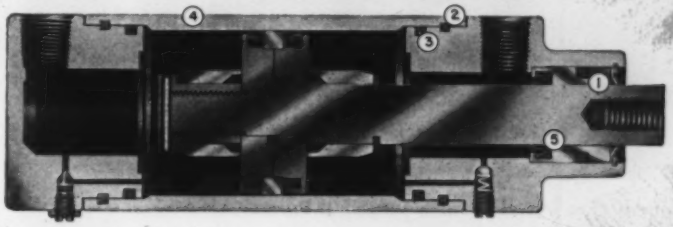
The same interview revealed that Americans believe the U. S. and Russia are about even in the race for scientific supremacy. Changes in the layman's appraisal of the scientific race immediately following the first Sputnik launching in October, 1957 and again in May of last year are evident in a comparison of poll results:

Public Feeling	Nov. '57	May '58
Russian science greatly superior	26%	8%
Russian science about the same	16	26
Russian science better in some areas	18	33
American science greatly superior	22	21
Not ascertained	18	12

Of interviewees who thought basic research in the physical sciences most important, half felt that Russion science is better than American in some areas, but not in others. A conclusion of the pollsters is: "It is apparent that much of the support for basic research comes from those who are best informed with regard to science. It reasonably follows that this support might be increased by making more scientific information available to the public."

Preference for basic research in the physical sciences increased with education. Even so, 47 per cent of those who had attended college put medical ahead of space projects.

CARTER
CYLINDERS
AIR OR HYDRAULIC



Designers get 3 Important Benefits by Standardizing on the Superior CARTER Design

THE CARTER DESIGN

1—Full 1 to 1 Meehanite cartridge rod bearing.

2—Key type stainless steel locking ring. Allows 360 rotation of ports.

3—Leakproof "O" Ring seal between head and wall.

4—Precision honed heavy wall tubing—6 to 1 safety factor.

5—Spring loaded "V" packing on rod end gland.

IMMEDIATE DELIVERY FROM STOCK

SAVINGS IN SPACE—40% savings in space. Helps build more compact, functional equipment. Where other cylinders won't fit, Carter will!

IMPROVES PRODUCT QUALITY Carter cylinders are stronger, more efficient. Completely leakproof! Better performance, longer life. The finest cylinder for your product.

ENGINEERING SERVICE and sales in 40 locations throughout the United States, Canada, Mexico, and Europe.

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Details on air, hydraulic, valves, built-in-valve types. All necessary data for designers.

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AIR CYLINDERS • AIR VALVES • HYDRAULIC CYLINDERS
ROTARY ACTUATORS • SPECIAL CONTROLS

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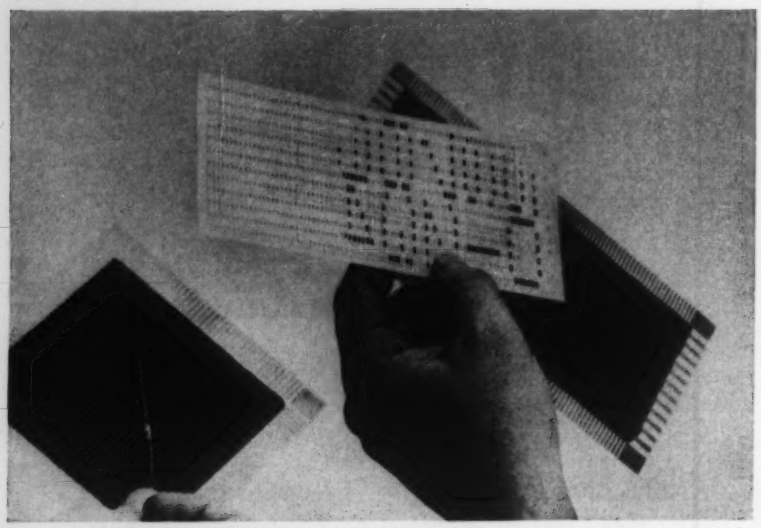
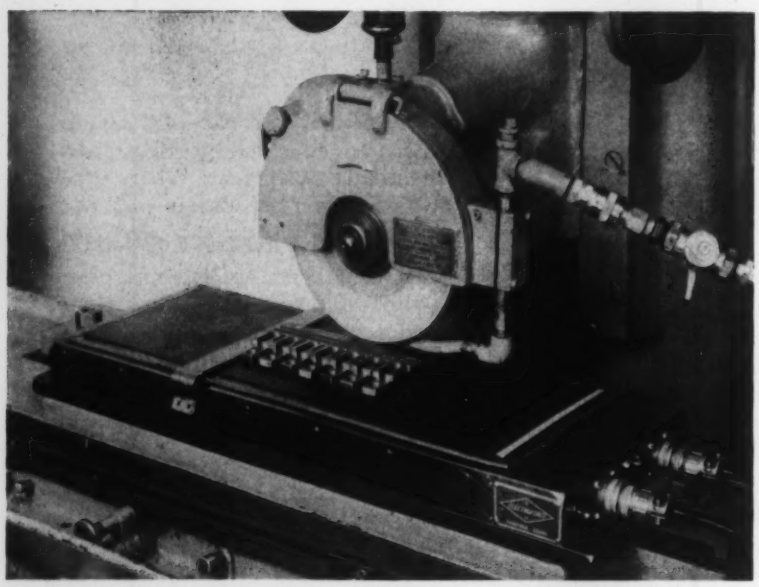


Photoactive Matrix Reads Punched Cards

Packing 3200 light-sensitive cells into a 4 by 8-in. area, photorectifier plates developed by MIT's Lincoln Lab. operate like tiny diodes. The cells rectify a current in the presence of light. Removal of light causes a sharp cutoff of operation, which makes possible programing of a computer by masking suitable parts of the array without expensive rearrangement and soldering. Imbedded in transparent plastic plate, the production model, called Rex-Array by Rex Corp., West Acton, Mass., is adaptable to any digital computer. Used with punched-card masks, it reads film, cards, characters.



Electrostatic Chuck Holds Any Metal, Some Nonmetals

All electrically conductive materials are held with positive rigidity in a new electrostatic chuck. Any solid nonmetallic material can also be held if chucking surfaces are flashed with a conductive coating only 5 millionths of an inch thick. Developed by Electroforce Inc., Fairfield, Conn., the new chucking equipment includes a Dri-Box in which the work is kept moisture-free at slightly above room temperature. A coolant pump and filter unit furnishes a supply of clean dielectric coolant. Chucking procedures are similar to those used in magnetic chucking, with work instantly gripped and released by a simple control switch. Chuck operates on 110-v, ac and is adaptable to standard machines.

Submarines Get Celestial Device To Supplement Inertial Guidance

WASHINGTON—Despite the uncanny accuracy of new inertial guidance systems, the Navy's nuclear-submarine fleet is being equipped with a device that relies on the old principles of celestial navigation. Called SCAR (for Submarine Celestial Altitude Recorder), the device has proved its worth in supplementing inertial systems during the record-breaking submerged voyages of Nautilus, Seawolf, and Skate.

As testimonial, Commander William A. Anderson, skipper of the Nautilus, says SCAR ranks with the development of the snorkel and the new Albacore hull design as a truly significant advance in submarining. It was developed by Sperry Piedmont Div., Sperry Rand Corp.

According to the Navy, SCAR is fitted into the submarine's periscope assembly and enables the undersea vessel to make a celestial fix on the moon, sun, or a star with only the periscope above surface. When a sighting is taken, a switch on the scope is pressed, and the exact altitude of the celestial body is computed automatically, giving the angle of sighting in degrees and the exact time. The timing device used is accurate to within 1 second per day. After two or more stars have been sighted, the navigating officer merely consults the Navy almanac and works out the sub's position.

Research Pool Announced by Investment Casting Institute

CHICAGO—To use research resources of the industry to greatest capacity without overlapping, the Investment Casting Institute has announced the organization of a co-operative technical research program. A central ICI committee has made a list of research projects of concern to manufacturers of investment castings. Each member company is expected to choose one of the listed projects, or suggest one of its own consistent with its size and research resources. Each member company will contribute one research study and will receive one from each of the other members.

insure..

HYDRAULIC SYSTEMS AGAINST DIRTY OIL WITH CFC FILTERS

When you OK the hydraulic system of a new machine, make sure it remains free from dirty oil contamination by specifying CFC Honan-Crane K-Type Filters. Developed especially to meet JIC specifications, this versatile filter is now standard on a wide variety of machine tools and equipment.

Two types of interchangeable cartridges provide micro-clarity of all kinds of mineral oils and synthetics. The Flo-Pac 5 resin-impregnated paper cartridge has over 6300 square inches of filtering surface. It is designed for high flow rates, full-flow or by-pass filtration, for water-base and additive hydraulic fluids.

The "T" Type Cartridge contains 13 pounds of Cranite (low volatile fuller's earth) to remove water, acids and asphaltenes as well as solid contaminants. It is recommended for non-additive type oils and certain synthetics.

The CFC line of filters includes Fulflo, Honan-Crane, Michiana and Delpark models for a wide variety of OEM applications. Send for complete catalog to Dep't MD

COMMERCIAL FILTERS CORPORATION
MELROSE 76, MASSACHUSETTS
PLANTS IN MELROSE, MASSACHUSETTS AND LEBANON, INDIANA

MICRO-CLARITY AT MINIMUM COST

Fulflo FILTERS — *with genuine Honeycomb Filter Tubes for controlled micro-clarity of industrial fluids.*

CFC FILTERS — *Selective filtration of oils • water-oil separators • magnetic separators • pre-coat filters • coolant clarifiers • automatic tubular conveyors.*

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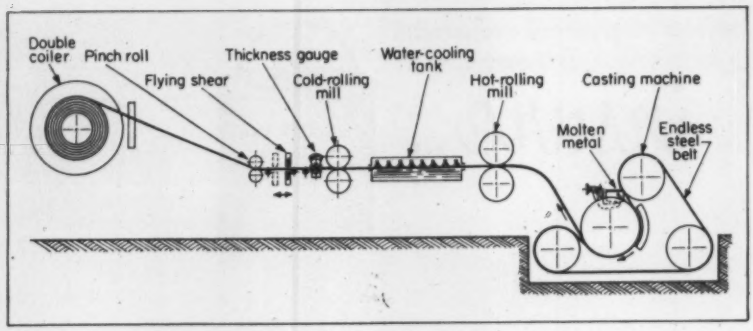
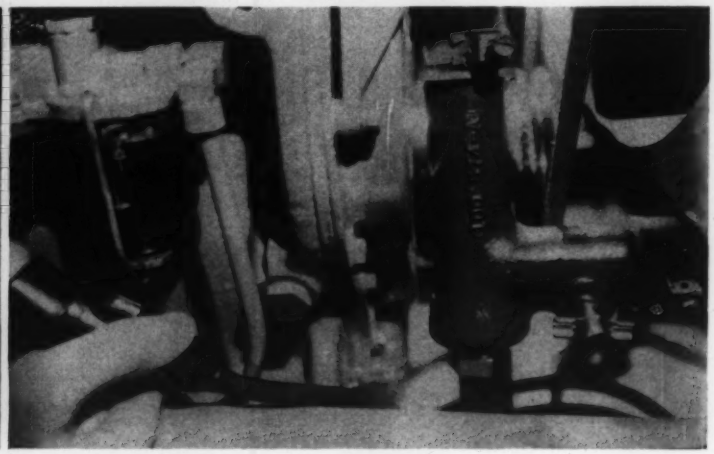


Three-In-One Casting Machine

Melting, casting, and rolling are one operation in this unique new machine that produces narrow-width aluminum strip. Heart of the machine is a 5 ft diameter wheel, left, with a trough-shaped groove along its circumference. Depth and width of the groove determine the size of the "slab" to be cast. The groove is closed for casting by an endless steel belt running along part of the casting wheel circumference and over three guide sheaves. Wheel and belt are water cooled to solidify the liquid metal as it travels along the wheel circumference. Developed by Lobeck Casting Processes Inc., the machine, in a typical installation, produces 4 tons of 1/8 x 8 in. type 3003 aluminum-alloy strip per hr.



Warm Start for Cold Tractors

An electric preheater in the cooling system gives this tractor fast, wear-free starts in cold weather. Installed in the lower water hose, the 1000-w immersion type heater raises radiator coolant temperature in the top rear head of the engine from 10 F to 50 in 1 hr. Heaters can also be installed in the oil pan to assure free flow of lubricant during cold engine turnover and further reduce wear on battery and starter. Developed as original equipment by General Electric Co., units plug into 110-v outlets and can be used on gasoline or Diesel engines.

Use of Burnable Plastics Ruled Out for Appliances

New U. L. Codes Will Affect Both Trim and Functional Parts

NEW YORK—"Only self-extinguishing plastics, or better, will be allowed in any part of any electrical appliance (refrigerators, television sets, radios, room air conditioners, etc.) as fast as Underwriters Laboratories Inc. can revise their specifications to so require." This statement was made following the recent meeting between U.L. officials and the U.L. committee on Basic Plastics and Room Air Conditioners.

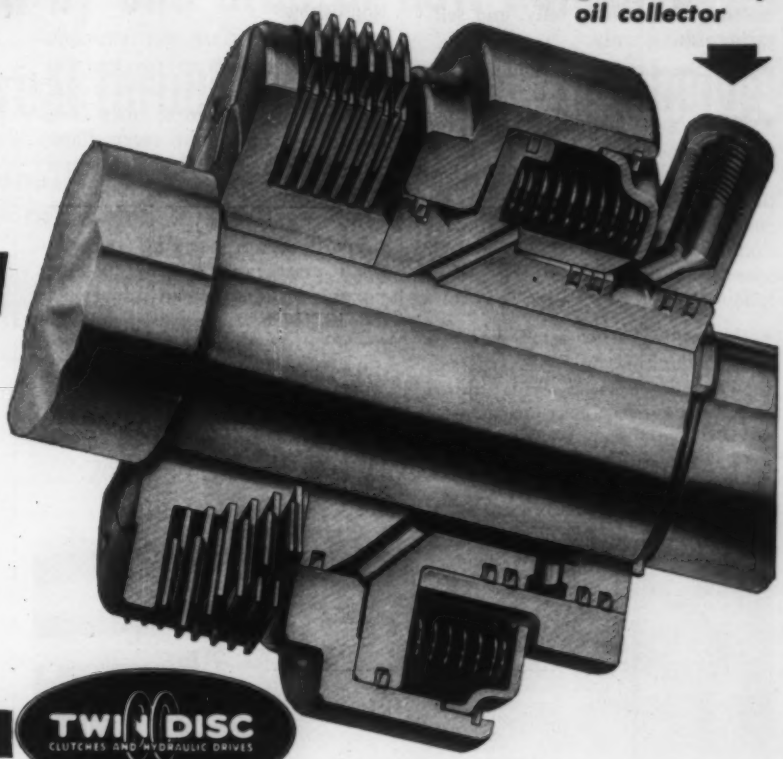
According to U.L. spokesmen, combustible plastics are replacing noncombustible materials at an "alarming" rate, and U.L.'s responsibility to its insurance-company stockholders and to the general public requires definite action to reduce fire hazards. First appliance to be affected is the room air conditioner, with early 1960 the target date for manufacturers' compliance with the revised codes.

Since, in U.L. opinion, the problem is merely one of time, they offer to modify the effective date of their new regulation on such noncritical applications as decorative grills and knobs. U.L. also offers to negotiate with each appliance maker as to:

- Which parts of the appliance have to be nonburning and non-

NEW Twin Disc Oil-Actuated Multiple-Plate Clutches

Now available with integral stationary oil collector

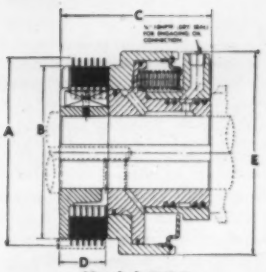


TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

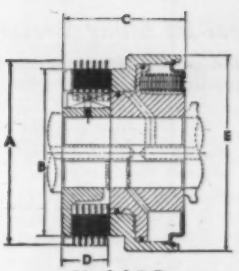
Clutch failures and burn-outs are virtually eliminated in these new wet-type Twin Disc Clutches. No adjustments are needed because ram travel compensates *automatically* for plate wear.

Designed for machine tools and similar applications, these units are built to run in oil and are actuated by oil pressure of 100 to 300 psi. Model DOC (shown above) has an around-the-shaft oil collector connected by a ¼" line. Model DO is identical except that the oil collector is omitted, shortening the clutch somewhat.

Compact design, smooth performance, long wear—with no adjustment problems—these benefits are available *now* in Twin Disc Oil-Actuated Multiple-Plate Clutches. Write for Bulletin 314.



Model DOC



Model DO

Model No.	Torque Capacity Lb.-ft.	Hp Capacity	Max. Allowable Rpm		A	B	C (length)	D	E
			With Hydraulic Balance	Without Hydraulic Balance					
DO-403	37	9	5000	2700	3.31	3.00	2.580—2.566	1.02	3.80
DOC-403			5000	3480			3.500—3.486		
DO-403½	95	20	5000	2680	3.81	3.50	2.892—2.872	1.17	4.42
DOC-403½			5000	3500			3.780—3.766		
DO-604	130	31	5000	2670	4.38	4.00	3.255—3.241	1.26	4.80
DOC-604			5000	3660			4.160—4.142		
DO-605	330	58	4500	2270	5.50	5.00	3.447—3.429	1.35	5.90
DOC-605			4500	3070			4.267—4.249		
DO-706	435	100	3750	1815	6.56	6.00	3.981—3.963	1.60	6.90
DOC-706			3750	2560			4.822—4.804		
DO-707	690	137	3250	1790	7.62	7.00	4.697—4.679	2.12	8.00
DOC-707			3250	2550			5.540—5.522		

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois

BRANCHES OR SALES ENGINEERING OFFICES: CLEVELAND • DALLAS • LOS ANGELES • NEWARK • NEW ORLEANS

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melting, nonburning only, and self-extinguishing only.

- Effective date of the requirements on each part.
- Minor modifications of test procedures for each part.

U.L. Bulletin 484, which outlines specific requirements for air conditioners and gives some indication of what may be expected of other appliances is being revised as follows:

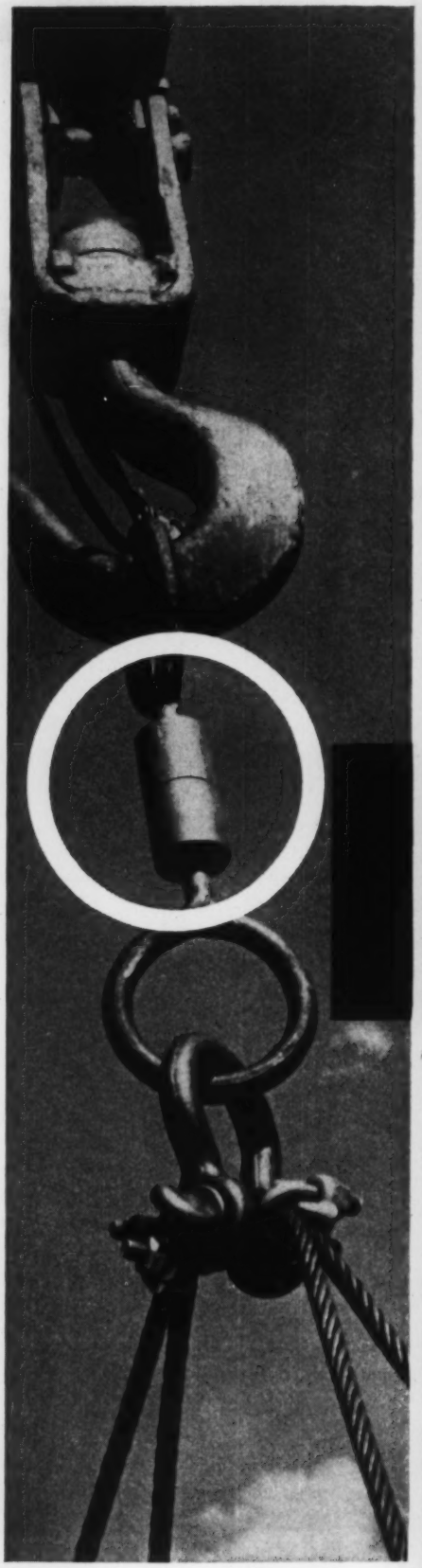
- Decorative grills and knobs—Parts submitted after October 1, 1960, must be self-extinguishing. Sample may drip, but drops must not carry flame.
- Noncritical parts made from plastic foams—Parts manufactured after January 1, 1960, must be self-extinguishing.
- Parts which are not structural and which do not support current-carrying-parts—These must be self-extinguishing. Sample may drip, but drops must not carry flame. This is required on all models manufactured after January 1, 1960.
- Structural parts or parts which support current-carrying parts — Parts must not continue to burn, nor melt to drip, when subjected to a 5-in. flame applied five times for up to 10 seconds each time. Parts must show no adverse effects after 7 hr at 302 F and no deterioration after 90 days at 240 F. This will be required on all models manufactured after January 1, 1960.

New Four-Jet Utility Stresses Safety

Safety and versatility are design keynotes in McDonnell Aircraft's new UCX 119 four-engine utility aircraft. Fatigue-resistant materials, low-stress pressure-vessel design, and wide usage of multiple-load paths contribute to structural safety. Separate, pod-mounted engines assure maximum freedom from multiple engine failure. As an additional safety feature, engine pods and pylons are strengthened to support the aircraft in event of wheels-up landing—to protect wing fuel tanks and cabin. Designed to meet both military and civil requirements, the craft uses a track mounting system on the cabin floor for seats, furniture, lavatory, training equipment, mounting racks, and other units. As a private transport the 119 will carry 10 passengers and a crew of two, or 8700 lb of cargo. Cruising speed exceeds 500 mph at 45,000 ft.

Tube Brightens Image

Intensity is multiplied by 1000 when a feeble 5-in. diam image is focused on the photocathode of this image intensifier to be transformed to an electron image and finally reproduced as a small, intense visual image on the 1-in. diam phosphor anode. Anode voltage, adjustable from 0 to 30 kv, controls image brightness. Westinghouse Corp. says the tube will react to intensity as low as 10^{-7} foot-candles.



2½ tons held by one drop of new adhesive demonstrates breakthrough in adhesive technology

Eastman 910 Adhesive opens way to new design approaches and faster, more economical assembly-line operations

One drop of Eastman 910 Adhesive is applied to the end surface of a 2-inch diameter steel rod, tapped to receive eye bolt.

The steel rod is held against the end of a similar steel rod for several seconds. The joined rods are then fitted with eye bolts and placed between a crane hook and lifting harness.

After setting for 30 minutes, the bond formed by one drop of Eastman 910 Adhesive supports a load of 5,000 pounds.

Here is a ready-to-use adhesive that sets almost instantly and develops high strength bonds in a matter of minutes. Moreover, it requires no heat, pressure or catalyst... and forms bonds with virtually all materials.

Eastman 910 Adhesive comes close to meeting the requirements of an ideal industrial adhesive. It is solving assembly problems for manufacturers of jet aircraft... trophies and jewelry... fountain pens... radiation measuring instruments... electronic components... rubber swimming masks... metal and plastic hand tools... and steel-backed rubber printing plates. In many cases this remarkable adhesive makes possible innovations in design previously considered impractical or impossible.

Look at its many features and see how you can take advantage of the unusual combination of properties available in this fast-setting, high-strength adhesive.

- SETS FAST–Makes unbreakable rubber-rubber bond in 30 seconds; bonds steel-steel firmly in 3 minutes.
- VERSATILE–Joins virtually any combination of wood, glass, metal, rubber, cork, leather, paper, porcelain, gems, minerals and most plastics.
- HIGH STRENGTH–Steel-steel bonds show shear strengths up to 3,800 psi, tensile strengths up to 4,600 psi, after 24 hours at room temperature.
- EASY TO USE–Thorough cleaning is the only surface preparation necessary. It is ready to use as supplied, no catalyst or mixing necessary.
- CURES AT ROOM TEMPERATURE–No heat is required to initiate or accelerate setting. Setting begins immediately upon spreading into a thin film.
- CONTACT PRESSURE SUFFICIENT–No pressure is required beyond that necessary to maintain good contact between surfaces.
- LOW SHRINKAGE–There is virtually no shrinkage on setting as neither solvent nor heat is used.
- GOES FAR–One-pound package contains sufficient adhesive for 13- to 14,000 one-drop applications to smooth, non-porous surfaces.

Eastman 910 Adhesive offers new opportunities for engineers, experimenters and fabricators in both design and production. It is ideal for applications where extreme speed of setting is desirable... or where design requirements involve small joining surfaces, complex mechanical fasteners or heat-sensitive assemblies. Eastman 910 Adhesive saves countless man-hours of production time.

To find out what it can do for you, send five dollars for a trial kit.

Developed by Eastman Chemical Products, Inc., subsidiary of Eastman Kodak Co., Kingsport, Tenn., Eastman 910 Adhesive is distributed world-wide by Eastman Chemical Products, Inc., Armstrong Cork Company and by their sales offices and agents.

Send for a trial kit. Each trial kit contains approximately ⅓ ounce Eastman 910 Adhesive in a polyethylene bottle with dispensing spout, instruction sheet and material for evaluation tests. Price... $5

Eastman 910 ADHESIVE

Send your order for the five dollar trial kit of Eastman 910 Adhesive to: Eastman Chemical Products, Inc., Chemicals Division, Dept. M-4, Kingsport, Tenn., or to: Armstrong Cork Company, Industrial Adhesives Division, 9104 Dean Street, Lancaster, Pa.

UNITED STATES
Eastman Chemical Products, Inc.
Kingsport, Tennessee
Wilson Meyer Company
San Francisco
Armstrong Cork Company
Boston (Needham Heights)
Chicago
Cincinnati
Cleveland
Detroit
Greenville, S. C.
Lancaster, Pa.
Los Angeles
New York City
Philadelphia
St. Louis

PUERTO RICO
A. Oscar Rivera, Inc.
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CANADA
Armstrong Cork Canada Limited
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Brussels, Belgium
S. A. Refic
Mouscron, Belgium
Kodak, Ltd.
Liverpool, England
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Ets. Randon & Immain, S. A. R. L.
Lille (Nord), France
Riberi S. R. L.
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Circle 418 on Page 19

TOPS 'EM ALL

IN QUALITY OF TUBING

Comparative quality tests by one of America's leading users of tubing proved only Precision Tubing rates excellent in all specifications . . . yet Precision Tubing costs no more.

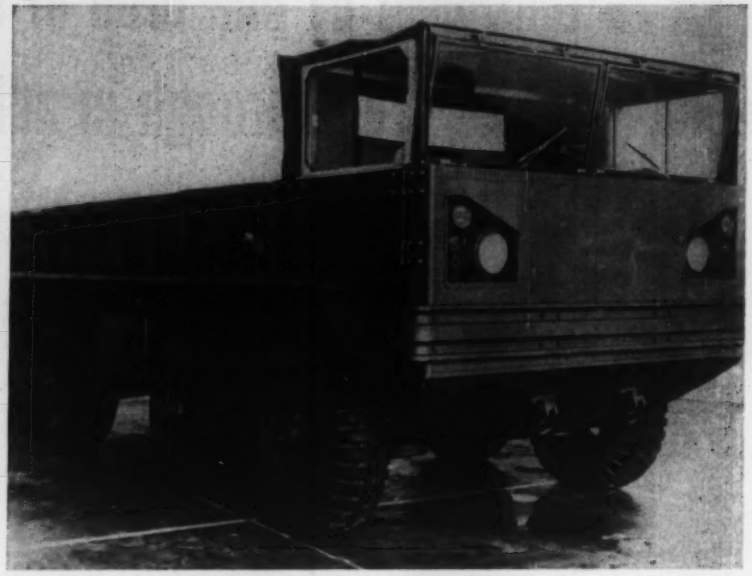
Precision Tubing is unequalled and unsurpassed in quality tests of accuracy, temper, straightness and roundness. You are sure of extra quality in every size tube at regular mill prices. Available in sizes from .010" to 1.125" O.D. in copper, brass, aluminum, up to ⅝" O.D. in nickel and nickel alloys, Ni-Span "C", phosphor bronze and nickel silver. In straight random lengths, coils or preformed shapes to specifications.

Write for catalog and technical data to Dept. 9, Precision Tube Company, Inc., North Wales, Pa.

GET THIS NEW TUBING DATA CATALOG

PRECISION TUBE COMPANY

Circle 419 on Page 19



Aluminum Army Truck Floats with Full Cargo

Fuel mileage will be increased by 50 per cent when the new eight-wheel XM410 replaces the present Army 2½-ton truck. The new aluminum truck, which is 5000 lb lighter than its 13,000-lb predecessor, is designed to float fully loaded. Ratio of payload to vehicle weight has been increased by 30 per cent. Power is transmitted through all eight independently suspended wheels. The Army will accept delivery of several of the new trucks from Chrysler Corp. for testing.

Meetings

AND EXPOSITIONS

April 19-23—

American Society of Mechanical Engineers. Oil and Gas Power Div. Conference and Exhibit to be held at the Shamrock-Hilton Hotel, Houston, Tex. Further information is available from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

April 20-22—

Metal Powder Industries Federation. Fifteenth Annual Meeting and Powder Metallurgy Show to be held at the Sheraton-Cadillac Hotel, Detroit. Further information can be obtained from headquarters of MPIF (formerly Metal Powder Association), 130 W. 42nd St., New York 36, N. Y.

April 21-23—

American Society of Lubrication Engineers. Fourteenth Annual Meeting and Lubrication Exhibit to be held at the Hotel Statler, Buffalo, N. Y. Additional information can be obtained from ASLE headquarters, 84 E. Randolph St., Chicago 1, Ill.

April 23-24—

American Society of Mechanical Engineers-Society for the Advancement of Management. Management Conference to be held at the Statler-Hilton Hotel, New York. Additional information can be obtained from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

April 25-30—

Scientific Apparatus Makers Association. Annual Meeting to be held at the Greenbrier, White Sulphur Springs, W. Va. Additional information is available from association headquarters, 20 N. Wacker Dr., Chicago 6, Ill.

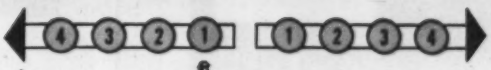
April 28-May 3—

Consulting Engineers Council. Third Annual General Meeting to be held at the Biltmore Hotel, New York. Further information is available from council headquarters, 326 Reisch Bldg., Springfield, Ill.

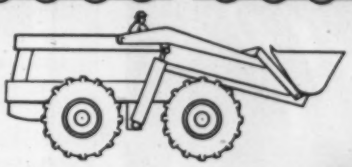
only the HYDRA-DRIVES® BDB

OFFERS ALL THESE MAJOR ADVANTAGES

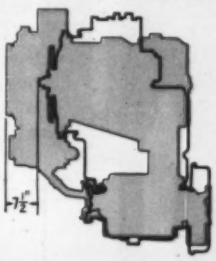
IN FULL-POWER SHIFT TRANSMISSIONS for equipment from 60 to 175 h.p.

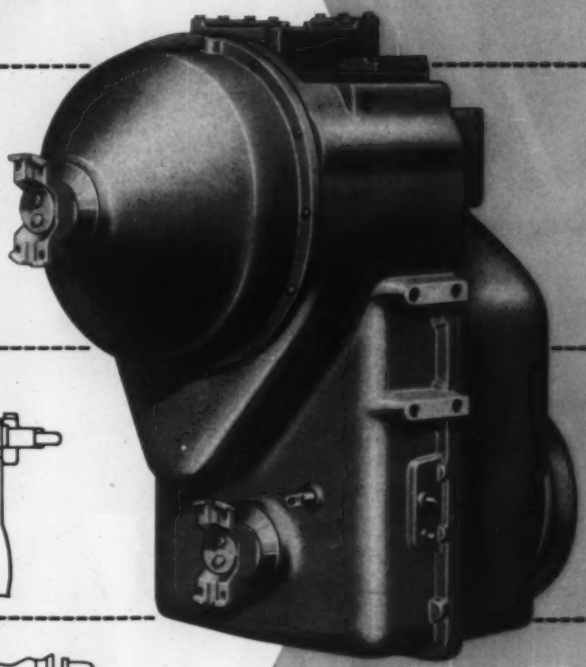


1. **4 speeds forward and reverse.** All power shifted! Provides maximum horsepower to load under all load conditions.

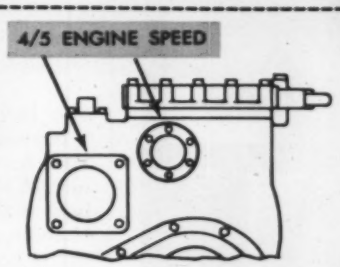


2. **Integral design.** Torque converter, transmission, oil passages, valving and oil sump are in *one* compact housing—7½" shorter than comparable models.

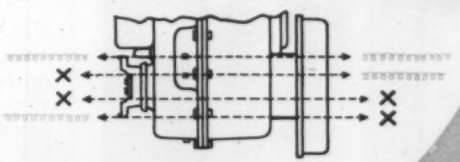




3. **Dual reduced speed pump drives.** Pumps can be driven at engine speed or ⅘ engine speed for longer life and increased horsepower to pump load. Single pump drive is also available.



4. **Full disconnect** provides four combinations of split drive . . . from torque on both shafts, to both shafts in disconnect.



SPECIALLY DESIGNED FOR SMALLER INSTALLATIONS

Rockwell-Standard's new model Hydra-Drives Full Power Shift Transmission is now available in sizes especially designed for smaller installations, such as front end loaders, fork trucks, scrapers, crane carriers, rubber tire tractors and military vehicles.

In addition, the Hydra-Drives BDB offers easier servicing and maintenance. There are fewer moving parts and bearings. The simple, rugged countershaft design and spur gears simplify maintenance.

HYDRA DRIVES
ROCKWELL-STANDARD CORPORATION
TRANSMISSION AND AXLE DIVISION
DETROIT 32, MICHIGAN

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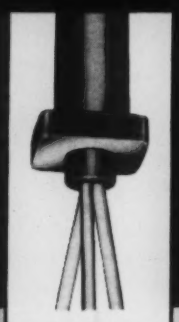
Circle 420 on Page 19

Couple YOUR
highly esteemed trademark with
CORNISH
and enhance your
prestige
Make CORNISH your headquarters for
CUSTOM
CORD SETS
MADE BY ENGINEERS FOR ENGINEERS
FOR FORTY YEARS we've specialized in the engineering and production of Blue Chip cord sets for Blue Chip electrical equipment and appliances. Let CORNISH machinery, men and methods help your fine products to serve better . . . LONGER. All our know-how at your service.
Consult Us Without Obligation
Support your local ADEQUATE WIRING BUREAU Program



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◆ ROCHESTER ◆ ST. LOUIS ◆ SAN FRANCISCO ◆ SEATTLE ◆ WILLIAMSTOWN
◆ Stock carried
Producers of Quality Wire Products for Home, Farm and Industry

April 29-May 1—

American Society of Mechanical Engineers. Metals Engineering Div. Conference to be held in Albany, N. Y. Further information is available from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

May 6-8—

Institute of Radio Engineers. Seventh Regional Conference and Electronics Exhibit to be held at the University of New Mexico, Albuquerque. Additional information can be obtained from conference headquarters, P. O. Box 3262, Albuquerque, N. Mex.

May 12-14—

American Society of Mechanical Engineers. Production Engineering Div. Conference to be held at the Statler-Hilton Hotel, Detroit. Additional information is available from society headquarters, 29 W. 39th St., New York 18, N. Y.

May 15-18—

National Fluid Power Association. Spring Meeting to be held at the Grove Park Inn, Asheville, N. C. Additional information is available from NFPA headquarters, 1618 Orrington Ave., Evanston, Ill.

May 18-20—

Instrument Society of America. Fifth Annual Symposium on Instrumental Methods of Analysis to be held at the Shamrock-Hilton Hotel, Houston, Tex. Further information can be obtained from ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

May 20-22—

Society for Experimental Stress Analysis. Spring Meeting to be held at the Sheraton Park Hotel, Washington, D. C. Additional information is available from R. O. Belsheim, 2475 Virginia Ave. N.W., Apt. 514, Washington 7, D. C.

May 25-28—

Design Engineering Show and Conference to be held at Convention Hall, Philadelphia. Conference is sponsored by the Machine Design Div. of ASME. Further information can be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Now . . . an old company presents a new face . . . an image . . . a dynamic trademark to match the many changes that are making Titeflex the most progressive company in the flexible hose business

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Circle 422 on Page 19

Circle 423 on Page 19→

Get dependable operation, increased

quality for your product . . .

GENERAL ELECTRIC TRI 55 CLAD MOTORS PROVE THEY PROVIDE IT BY PASSING TORTURE TEST

HERE'S HOW: G-E Tri/Clad '55' polyphase motors are more fully enclosed than ordinary dripproof motors. This extra protection makes them suitable for many jobs which normally require splashproof motors . . . extra protection at no extra cost.

Mylar* polyester film slot and phase insulation, non-wicking leads, and water-resistant stator coating give long-life protection against *moisture*. Formex† magnet wire provides protection against heat-aging and *dirt*. Heavy-duty bearing system keeps lubricant in, abrasive dust out. And rigid cast-iron frame and endshields and melamine paint finish protect G-E motors against *external damage*.

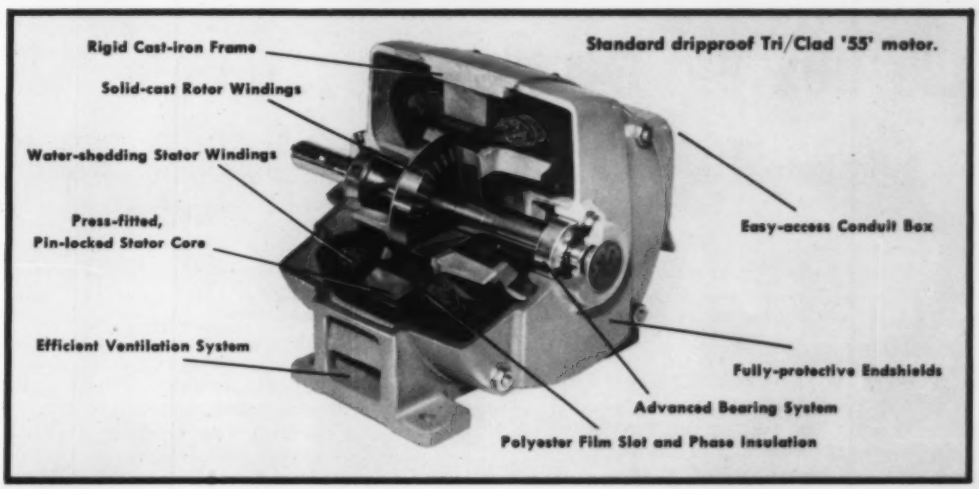
*Registered Trade-mark of DuPont Co.

These are just some of the outstanding Tri/Clad '55' motor features which mean longer life, more dependable operation—improve the quality and saleability of your product at no extra cost to you *or* your customers!

CONTACT your nearest G-E Apparatus Sales Office for *personal proof* on how G-E Tri/Clad '55' motors can give better operating protection to your products. And ask for your free copy of descriptive bulletins, GEA-5980 and GEA-6602, or write to Section 840-19, General Electric Company, Schenectady 5, New York.

†Registered Trade-mark of General Electric Co.

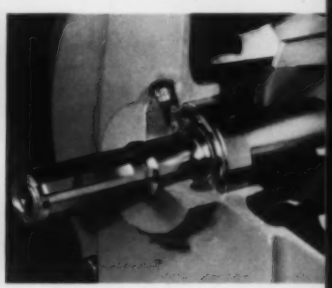
GENERAL ELECTRIC



Mylar Insulation protects against moisture; assures longer motor life, minimum maintenance.

Water-resistant Coating applied to every stator assembly virtually eliminates insulation failure due to moisture.

Formex Wire insulation will not break under severe conditions—protects against heat-aging and abrasive dust.



Long-life Bearing System seals dirt out, has new longer-lasting grease, can be regreased.

Take a cost-wise look at your assembly operations,

and you'll see that fasteners

represent real money. To make sure

it is money saved—not lost—

count on *Continental*

MORE TYPES OF FASTENERS Continental Assembly Specialists are unbiased toward any particular types . . . Continental makes all types. The fastener they recommend for your job is the one proved best by careful cost analysis.

MORE STANDARDS IN STOCK Continental can supply any recognized standard type, style or size. Also, many fasteners ordinarily considered "specials" are available among the millions of screws constantly in stock to meet needs of Continental customers.

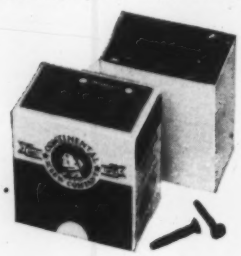
MORE "SPECIAL" EXPERIENCE Continental is known throughout industry as the "specialist in specials," — leads in production of special designs. Continental is also your supply source for special-purpose fasteners, such as HOLTITE NYLOK Self-locking Screws.

MORE "SPECIAL" PRODUCTION FACILITIES With Continental's modern, precision controlled equipment, many special shaped screws formerly machined from bar stock can be produced faster, at lower cost — with higher tensile strength and excellent surface quality.

Let Continental Assembly Specialists analyze your operations and help you find cost-saving opportunities that are often overlooked. You'll see why fastener users everywhere agree, *"You can count on Continental."* Write or phone: Continental Screw Co., 461 Mt. Pleasant St., New Bedford, Massachusetts.

CONTINENTAL
SCREW COMPANY, NEW BEDFORD, MASS.
HOLTITE FASTENERS

HY-PRO TOOL COMPANY . . . DIVISION
RESEARCH ENG. & MFG., INC. SUBSIDIARY



HOLTITE PHILLIPS AND SLOTTED HEAD
WOOD • MACHINE • TAPPING
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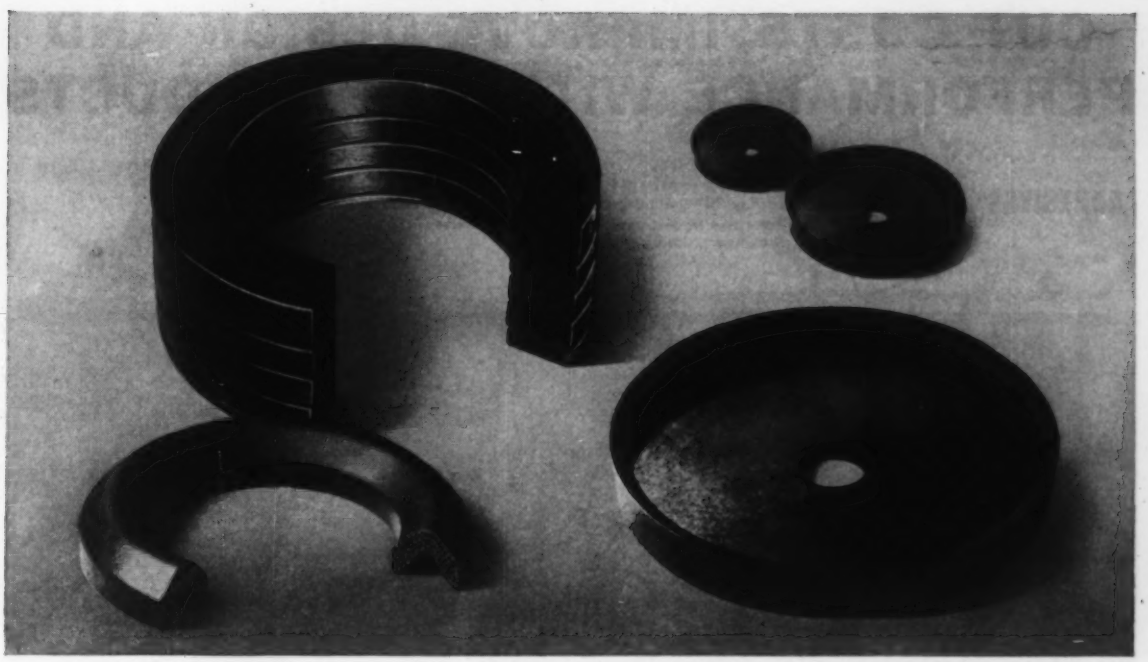
HY-PRO PHILLIPS INSERT BITS AND HOLDERS



R/M Vee-Flex Rings seal automatically and will not roll.

R/M Fabric Piston Cups are precision molded and cleanly trimmed.

PRECISION QUALITY CONTROL MEANS YOU CAN RELY ON R/M V-RINGS AND PISTON CUPS

R/M Vee-Flex® Rings give better performance and cut maintenance costs for your customers. Convex curvature of the surface which touches the next ring makes them self-sealing and self-adjusting. Pressure stroke produces a seal against the stuffing box wall and the adjacent ring. Friction is reduced on the return stroke. Precision molding and trimming give you the best possible fit—and provide longer wear, because the fabric is deeply penetrated by the compound. Use them on steam or air rods, hot oil pumps, hydraulic rams, outside-packed plunger pumps, food handling machinery, accumulator and elevator rams on oil or water service.

R/M Fabric Piston Cups provide minimum friction, long life and accurate fit. Molded from a variety of rubber synthetics with fabric reinforcements to suit your specific requirements. You can see the big difference in their clearly defined contours and cleanly trimmed edges—proof of strict adherence to industry standard sizes. R/M Fabric Piston Cups fit hydraulic and pneumatic cylinders ranging in diameter from ½ to 12 in. They are produced in varying degrees of hardness for pressures up to 1500 psi and in compounds to meet your specific operating conditions. When ordering piston cups, specify R/M.

Complete information on these and many other R/M Packings is given in this free booklet. Send for it today.

R/M MAKES A COMPLETE LINE OF MECHANICAL PACKINGS—Vee-Flex®, Vee-Square,® Universal Plastic, and "versi-pak"®; GASKET MATERIALS; "TEFLON"* PRODUCTS, including flexible wire-braided and rubber-covered hose. SEE YOUR R/M DISTRIBUTOR.

*A. Du Pont trademark

R/M PACKINGS
RAYBESTOS-MANHATTAN, INC.
PACKING DIVISION, PASSAIC, N.J.
MECHANICAL PACKINGS AND GASKET MATERIALS

RAYBESTOS-MANHATTAN, INC., Mechanical Packings • Asbestos Textiles • Industrial Rubber • Engineered Plastics • Sintered Metal Products • Abrasive and Diamond Wheels
Rubber Covered Equipment • Brake Linings • Brake Blocks • Clutch Facings • Industrial Adhesives • Laundry Pads and Covers • Bowling Balls

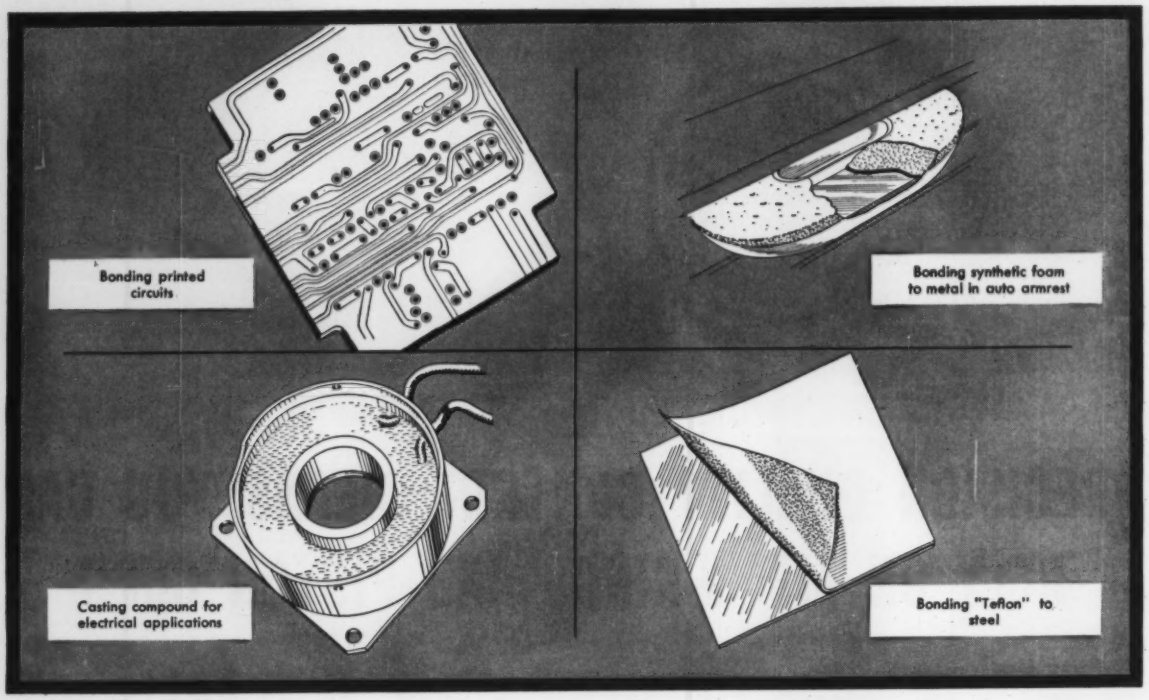
Circle 425 on Page 19

CUT COSTS, IMPROVE DESIGN AND PERFORMANCE WITH R/M PRODUCTS

ADHESIVES

Send for free copy of R/M Bulletin No. 700. Contains full information on Ray-BOND adhesives, protective coatings and sealers.

Adhesives Department, Raybestos-Manhattan, Inc.
Bridgeport, Conn.


Bonding printed circuits
Bonding synthetic foam to metal in auto armrest
Casting compound for electrical applications
Bonding "Teflon" to steel

For these and 1001 other applications —New R/M Ray-BOND Adhesives

The number of new places you can use adhesives today is growing faster than ever. With new bonding techniques and modern Ray-BOND adhesives, you can design reduced fastening time and costs into a variety of applications never before possible.

R/M Ray-BOND adhesives are of two different types—thermosetting and thermoplastic. They are available in different degrees of viscosity—for either spraying or painting. They give top performance under the most severe operating conditions —withstand temperature extremes ranging from –80° to +700°F.

Whether or not you have yet considered bonding, sealing, casting or coating in your own operations, talk to an R/M engineer about new Ray-BOND adhesives. Over 20 years' pioneering in the production of bonded assemblies and the manufacture of adhesives and coatings has given Raybestos-Manhattan a wealth of knowledge and experience that could well help you find new ways to improve your product and cut your production costs.

For special requirements R/M will tailor special adhesives . . . to meet your individual needs.

R/M

Brake Blocks, Linings and Clutch Facings

Mechanical Packings and Gaskets

Abrasive and Diamond Wheels

Industrial Drive Belts

Industrial and Automotive Hose

Conveyor Belts

Circle 426 on Page 19

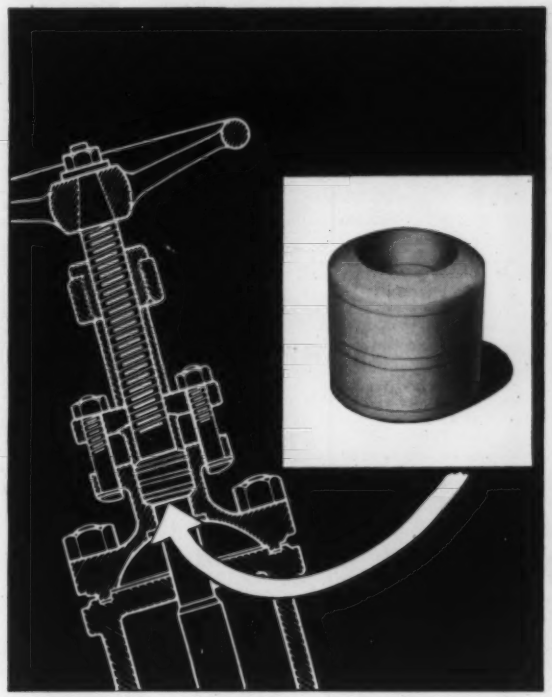
SPECIALISTS IN ASBESTOS, RUBBER, SINTERED METAL, ENGINEERED PLASTICS

PACKINGS

Complete information on packings shown and many others is given in free booklet. Send for it today.
Packing Division, Raybestos-Manhattan, Inc.
Passaic, N.J.

RUBBER

Write today for free booklet shown: full details on a wide variety of industrial rubber products.
Manhattan Rubber Division, Raybestos-Manhattan, Inc.
Passaic, N.J.



R/M Valve Stem Packings are available in many formulations for varied needs.

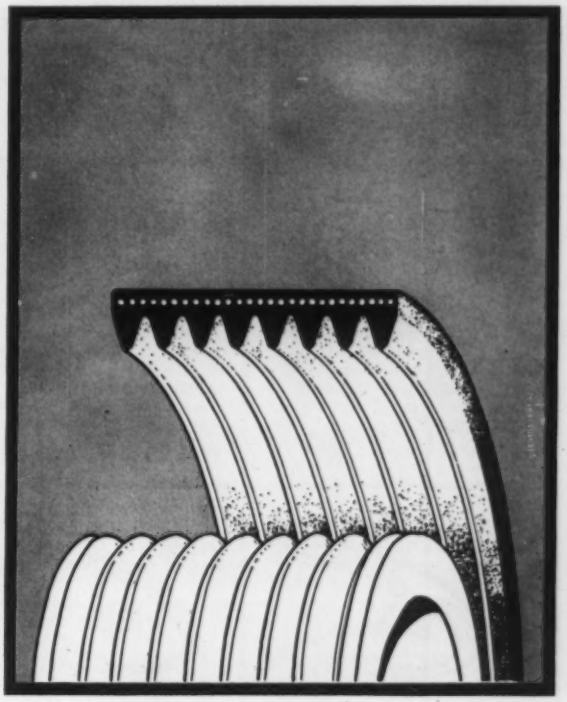
Close fit, long wear with R/M valve stem packings

You get the benefit of R/M's long experience as a leader in the packing industry when you select valve stem packings made by Raybestos-Manhattan. R/M engineers, working in superb laboratories, have perfected or can perfect packings to meet your most exacting requirements, whether you are coping with extremes of temperature, extremes of pressure, or corrosive materials.

Corrosive materials, for example, do not harm R/M "Teflon"* valve stem packings. These packings, supplied in wedge type, angular type, and solid unit rings, are ideal for all kinds of valve stems. They will give you outstanding performance in equipment handling acids, alkalies or solvents. They are recommended for slow-moving reciprocating rods on measuring and blending equipment.

Whatever your packing needs, feel free to call on R/M.

*A Du Pont trademark



R/M Poly-V Drive, more power—less space

No other belt drive delivers as *much* power in as *little* space as R/M's patented Poly-V* Drive. Poly-V's single, endless parallel V-ribbed belt runs on grooved sheaves to mate precisely with belt ribs . . . gives the drive *twice* the tractive surface to deliver up to 50% more power in the same space as a V-belt drive—or equal power in as little as ⅔ the space! This means less shaft overhang . . . a more compact, lighter drive. Single unit design eliminates belt matching problems, helps maintain constant pitch diameter and speed ratios from *no* load to *full* load. Just two cross sections of Poly-V Belt meet *every* heavy duty drive design requirement!

R/M specialists will work with you wherever you need Poly-V Drives, flat transmission or V-belt drives, conveyor belts, hose, molded or other rubber products.

*Poly-V is a registered Raybestos-Manhattan trademark.

RAYBESTOS-MANHATTAN, INC.

FACTORIES: Passaic, N.J. • Bridgeport, Conn. • Manheim, Pa. • Paramount, Calif. • No. Charleston, S.C. Crawfordsville, Ind. • Neenah, Wis. • Peterborough, Ontario, Canada

Rubber Lined and Covered Equipment

Sintered Metal Friction Elements

Asbestos Textiles

Industrial Adhesives

Teflon Tape, Packings, Sheets, Rods, Tubes

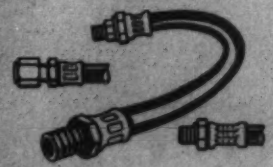
Engineered Molded Rubber and Plastics

Circle 427 on Page 19A

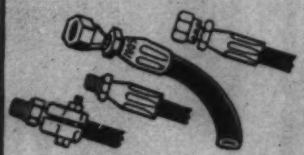
Circle 428 on Page 19A

YOUR ONE BEST SOURCE FOR

Everything in Hydraulic Hose

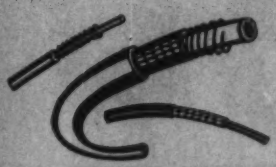


FACTORY PRESSED-ON ASSEMBLIES—Standard hose assemblies or to your specifications.

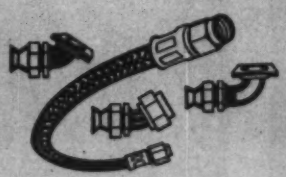


FIELD-ATTACHABLE FITTINGS—Popular for replacement . . . Easy-Grip hex requires no special tools.

BULK HOSE—Most complete range of types and sizes, for all industrial, automotive, and aircraft requirements.



LOW PRESSURE HOSE—Flexonics offers the most extensive line of low pressure hose available today.



TEFLON* HOSE—Flexonics offers a full range of stainless steel braided Teflon for steam and chemical applications.

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EXPERT ENGINEERING—To assist in the selection and design of hose assemblies for your application.

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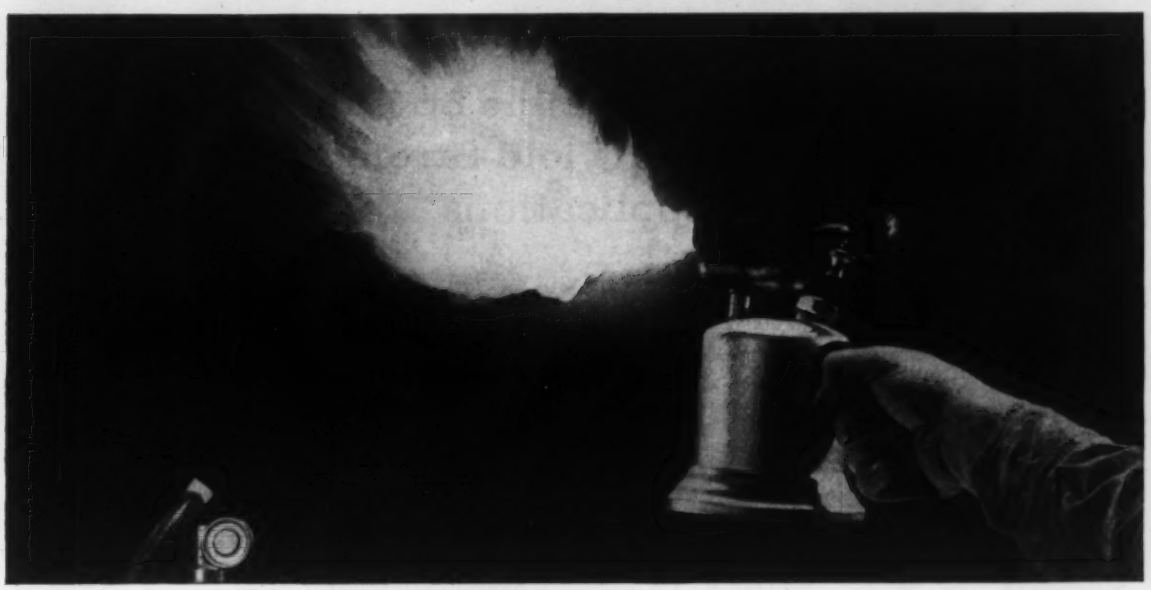
In Canada: Flexonics Corporation of Canada, Limited, Brampton, Ontario

Circle 429 on Page 19

Why the new interest in flame retardance of plastic laminates?



Sheet of Synthane to which blowtorch is being applied

While it is unlikely you will ever take up your blowtorch to sample the flame resistance of laminated plastics, this property emerges as a lively topic for discussion among engineers.

Admittedly its import is for the councils of those whose equipment is flame-exposed or is powered, amplified or controlled by vacuum tubes and upon which, clustered or confined, you could properly fry an egg.

Under the circumstances, it is appropriate to ask what laminated plastics (or Synthane, to name our choice) have to offer in the way of flame retardance, and how this property relates to the other, and more widely used, advantages of laminates.

Two Specific Flame Retardant Laminates

There are two grades of Synthane laminates specifically earmarked for flame retardance—Grades FR-1 and FR-2. Except for its flame retardance, Grade FR-1 closely resembles standard paper base phenolic Grade XX Synthane. Grade FR-2 is similar to Grade FR-1, but may be readily hot punched and would be used where flame retardance with emphasis on punchability was desired.

Many Grades of Synthane Self Extinguishing

Many standard grades of laminates—though they contain no flame retardant additives—are self extinguishing. That is, they do not support combustion when the flame is removed.

For example, the fabric and glass melamine grades are excellent for their self-extinguishing characteristics. The same is true of the asbestos grades. Why, then, special flame retarding grades? The answer is partly financial.

The flame retardant grades FR-1 and FR-2 offer good electrical and mechanical properties (similar to Grade XX) plus excellent flame retardance and at a moderate cost. When the electrical or mechanical requirements are severe it is they that may control the choice of laminate even though flame retardance is still necessary. And it just so happens that the cost of producing grades with superior electrical and mechanical properties tops the cost of producing flame-retardant Grades FR-1 and FR-2.

Comparison of Properties of Synthane Laminates with Relation to Flame Retardance

	GRADES										
Property	FR-1	FR-2	XX	C	L	C-M	L-M	G-5	G-8	A-M	AA-M
Flame Retardance	E	E	P	P	P	E	E	E	E	E	E
Heat Resistance	F	F	P	P	P	G	G	E	E	E	E
ARC Resistance	P	P	P	P	P	E	E	E	E	E	E
Mechanical Strength	F	F	F	G	G	G	G	E	E	G	G
Dimensional Stability	F	F	F	F	F	G	G	E	E	E	E
Moisture Resistance	E	E	G	G	G	G	G	E	E	E	E
Dielectric Strength	E	E	G	F	F	F	F	E	E	F	F
Machinability	E	E	E	E	E	E	E	F	F	F	F
Cost	Lowest	Low	Lowest	Low	Mod	Mod	Higher	Higher	Mod	Lowest	Higher

E = Excellent, G = Good, F = Fair, P = Poor

Obviously there is more to this business of selecting an electrical insulation than flame retardance. In any spot where flame retardance is a factor it is prudent to counsel with us, directly or through our representatives, to secure for yourself the Synthane Grade which supplies *all* of the properties you need *in combination* and at a reasonable cost. Our aim is to help you obtain the most for your money so that you may find coming to us a profitable habit.

For further information about Synthane standard or flame retardant grades write Synthane Corporation, 5 River Road, Oaks, Pa.

Flame retardant test on Synthane for switchgear application. Heat is supplied by coil encircling the sample. Temperatures up to 1600°-1800°F are measured with optical pyrometer.

SYNTHANE

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Laminated Plastics for Industry

Sheets, Rods, Tubes, Fabricated Parts
Molded-laminated, Molded-macerated

Circle 430 on Page 19

Memo on Metals

New Study Shows Crucible 56 Offers the Stability, Tensile and Yield Strengths Needed in 800—1000° F. Applications

A recent study considers three steels which show promise of solving the high temperature strength problems encountered in today's high speed flight.† These problems of maintaining structural strength at elevated temperatures are further complicated by the need for favorable strength/weight ratios.

Two of the steels are hot work types (Crucible 218 and 56) that are only now being considered for structural applications in aircraft. Crucible 56 is a relatively new steel, offering an unusually high level of stability at high temperatures. The chemistries of the three steels are as follows:

CHEMICAL COMPOSITION

Grade	C	CR	Ni	Mn	Mo	V	Si	Al
Crucible 56	.40	3.30		.60	2.75	.40	1.00	
Crucible 218	.38	5.20		.35	1.40	.50	1.10	
AISI 4340	.40	.80	1.80	.70	.25		.30	

Figs. A and B compare the tensile and yield strengths of the three steels at the exposure temperature. The curves show that both Crucible 56 and Crucible 218 proved superior in these tests. However, the hardness-tempering curve for Crucible 56 shows that it is more stable than the other analyses evaluated. Crucible 56 also offers higher hardness (and hence, strength) when tempered in the 1050-1100° F. range. As the comparisons indicate, it also has higher elevated temperature tensile and creep properties than Crucible 218, which is a conventional AISI type. In Fig. C, the isochronous (constant time) stress-strain curves illustrate the stability of Crucible 56 at the top of the service temperature range. With these curves it is possible to determine the stress at which creep becomes an important consideration.

For further details on Crucible 56 and other comparative data, send the coupon.

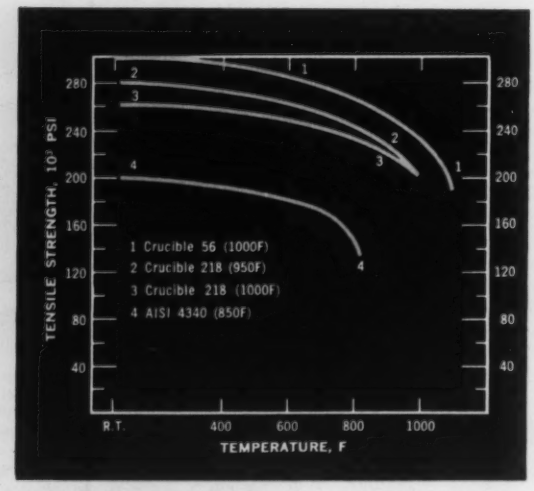


Fig. A. Tensile strength of various steels at exposure temperatures. Figures in parentheses are tempering temperatures.

†Although this study considers only aircraft applications, data given here may prove helpful in designing turbines, chemical processing and nuclear equipment, and other equipment where service temperatures ranging from 800-1000° F. are required.

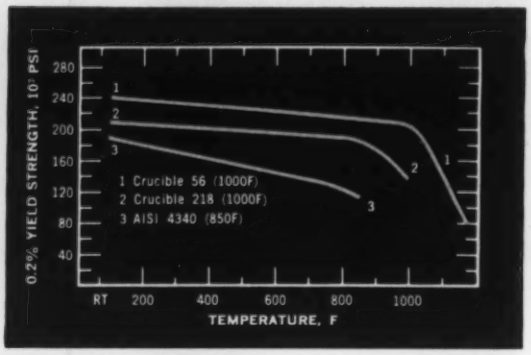


Fig. B. Yield strength (0.2% off-set) of various steels at exposure temperatures. Figures in parentheses are tempering temperatures.

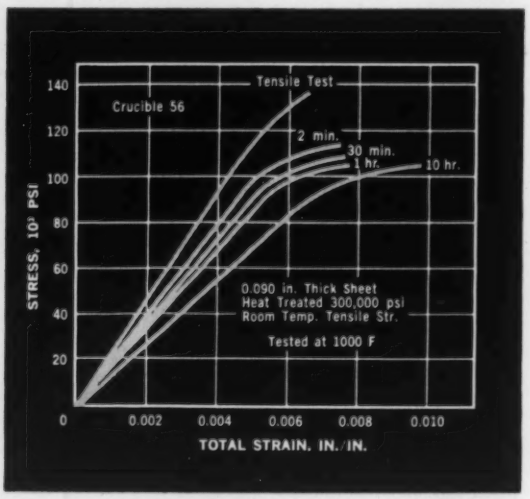


Fig. C. Isochronous stress-strain curves for Crucible 56 sheet show the outstanding creep properties of this steel which are higher than any other steel at 1000° F.

* high temperature strength
* vacuum melting
* cast properties of UHS-260

Compares properties of bearing steels produced by various melting techniques

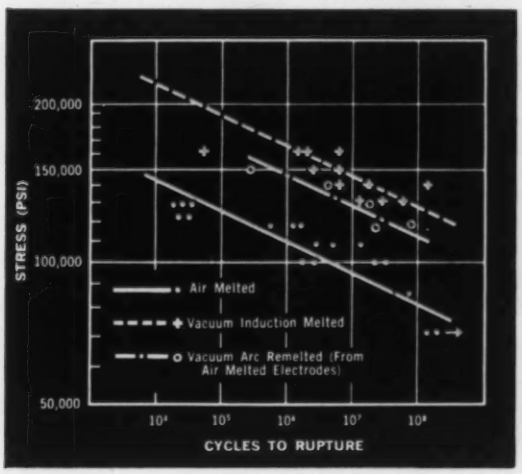
High vacuum technology has expanded considerably in recent years. The degree of improvement obtainable can be shown by comparing the properties of SAE 52100 produced by various melting techniques.

The following table gives gas content analyses of this chromium-carbon steel when produced by air melting (AM), air melting and vacuum arc remelting (AM+VAR), vacuum induction melting (VIM) and double melting (VIM+VAR):

Melting Technique	O(PPM)	N(PPM)	H(PPM)
AM	30	100	<1
AM+VAR	7	70	<1
VIM	5	3	<1
VIM+VAR	3	3	<1

Reduction in gas content is important, of course, because gases have varied detrimental effects on alloys. Oxygen increases transition temperature and forms various types of inclusions. Nitrogen effects aging, fatigue and stress rupture.

Similar improvement is obtained in cleanliness. (Inclusions strongly influence properties such as fatigue, impact and ductility.) Vacuum induction melted 52100 shows very small sulphide and oxide inclusions. Its background is extremely clean. Vacuum arc remelted 52100, made from air melted electrodes, also shows significant improvement over the air melted steel. Still further improvement is available with double melting.



Up to now, vacuum melted 52100 has been used mainly in bearings for jet engines, grinder spindles and instruments. It is credited with extending "B-10" life (the life at which 10% of the bearings fail) from 65 hours to 375 hours. Premature failures have been virtually eliminated. And the average number of production rejects of finished balls has dropped from 15% to 0.3%—savings that in some cases pay for the slightly higher cost of the vacuum melted alloy.

For more data on vacuum melted SAE 52100—or data on other vacuum melted ferrous and non-ferrous metals and alloys—send the coupon.

UHS-260 in cast form offers high strength with good ductility

New studies of the cast properties of UHS-260 should prove interesting to designers of structural parts for aircraft. In cast form at high temperatures, UHS-260 offers very high tensile strength with ductility equal to or better than transverse properties of the wrought form. Data from a preliminary report is given below. *For more complete information send the coupon.*

Grade UHS-260 Cast Properties —Preliminary Report

Nominal Composition

C	Si	Mn	Mo	Cu	Fe	Cr	Ni	V	Condition
0.35	1.50	1.35	0.30	—	Bal.	1.25	—	0.30	Hardened & Tempered

Mechanical Properties

	Test Temp °F.	Tensile Strength psi	Yield Strength psi	% Elong	% R.A.	Charpy Impact
Mean	−40°	265,000	218,000	6	10.5	7
High		268,000	226,000	6.5	15	8
Low		262,000	213,000	4	9	6
Mean	76°	260,000	217,000	4.5	12.5	7.7
High		265,000	241,000	6	16	8
Low		257,000	211,000	4	7	6
Mean	400°	266,000	191,000	5	7.3	11
High		269,000	205,000	6	10	13
Low		261,000	183,000	4	5	9
Mean	600°	237,000	162,000	9	18	11.3
High		240,000	172,000	10	23	12
Low		234,000	153,000	8	13	10
Mean	800°	200,000	147,000	9.6	29	12.3
High		232,000	179,000	13	42	13
Low		189,000	131,000	3	4	12

CRUCIBLE STEEL COMPANY OF AMERICA
Dept. ED07, The Oliver Building
Mellon Square, Pittsburgh 22, Pa.

Gentlemen:

Please send me the following:

1. Crucible 56 Data Sheet_____ Comparative Data_____
2. Data sheet on vacuum induction melted SAE 52100_____
3. Data on other VIM metals_____
4. Further information on the cast properties of UHS-260_____

Name_____

Title_____

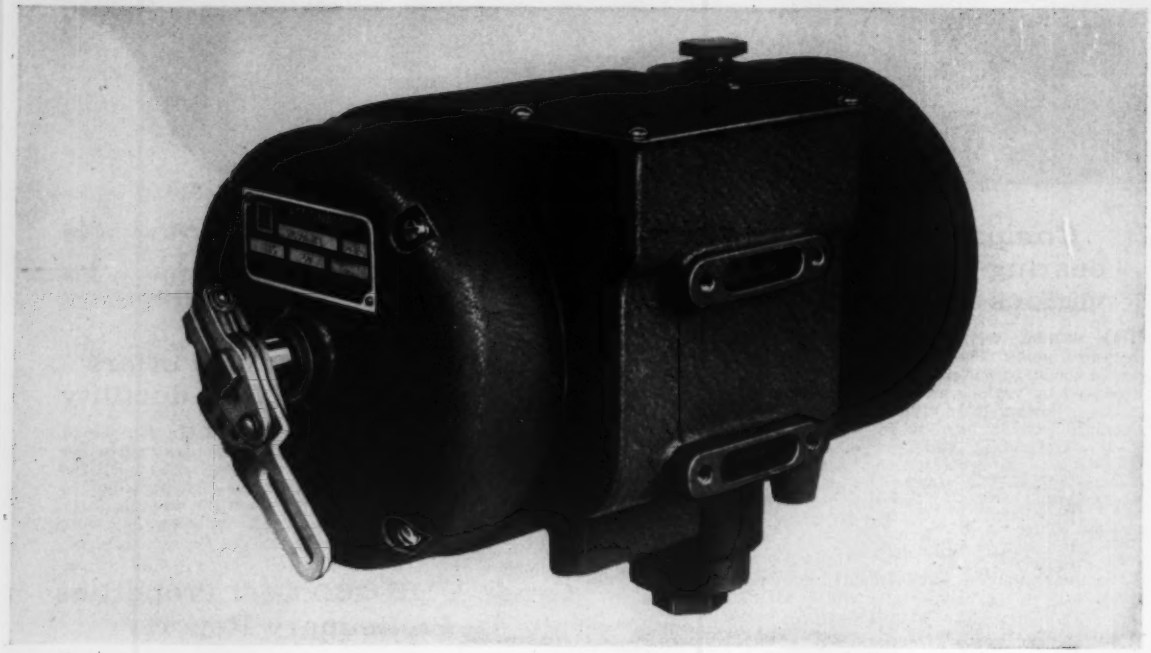
Company_____

Street_____

City_____ Zone_____ State_____

CRUCIBLE STEEL COMPANY OF AMERICA

Circle 432 on Page 19



NEW ACTIONATOR* heavy-duty electric motors operate slip stem valves

Use the powerful new ACTIONATOR industrial type motors to operate vertical acting stem valves having lifts of ½ inch through 1½ inches. Double-ended shaft can also simultaneously operate butterfly valves, rotary stem valves and other devices through suitable linkages.

ACTIONATOR motors are available with a variety of speeds, from 7.4 to 120 seconds full-stroke operation. The high speed permits use with pulse-type controllers such as those used in radiant tube firing. Torque ratings range to 200 inch/lbs.

*Trademark

Other features include built-in linkage and strain relief, mounting yoke, and enclosed terminals with gasketed housing to meet JIC specifications.

Models are available with two-position, floating and proportional control. Optional models can include either one or two cam-operated, internally mounted switches for a variety of dual switching purposes. The compact assembly is self-supporting and requires no auxiliary mounting bracket. Other ACTIONATOR motors are available for use with rotary shaft type valves, dampers, louvers, or other final control elements.

Get complete details from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone.

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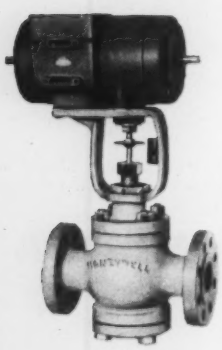

Choose valve bodies to work with ACTIONATOR motors from Honeywell's complete line of single-seated, double-seated and three-way types.

Honeywell

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JUST OUT! 52-page book...

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"Architecture and Allegheny Stainless" is filled with facts vital to everyone concerned with architecture and buildings. Write today for your free copy. *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.*
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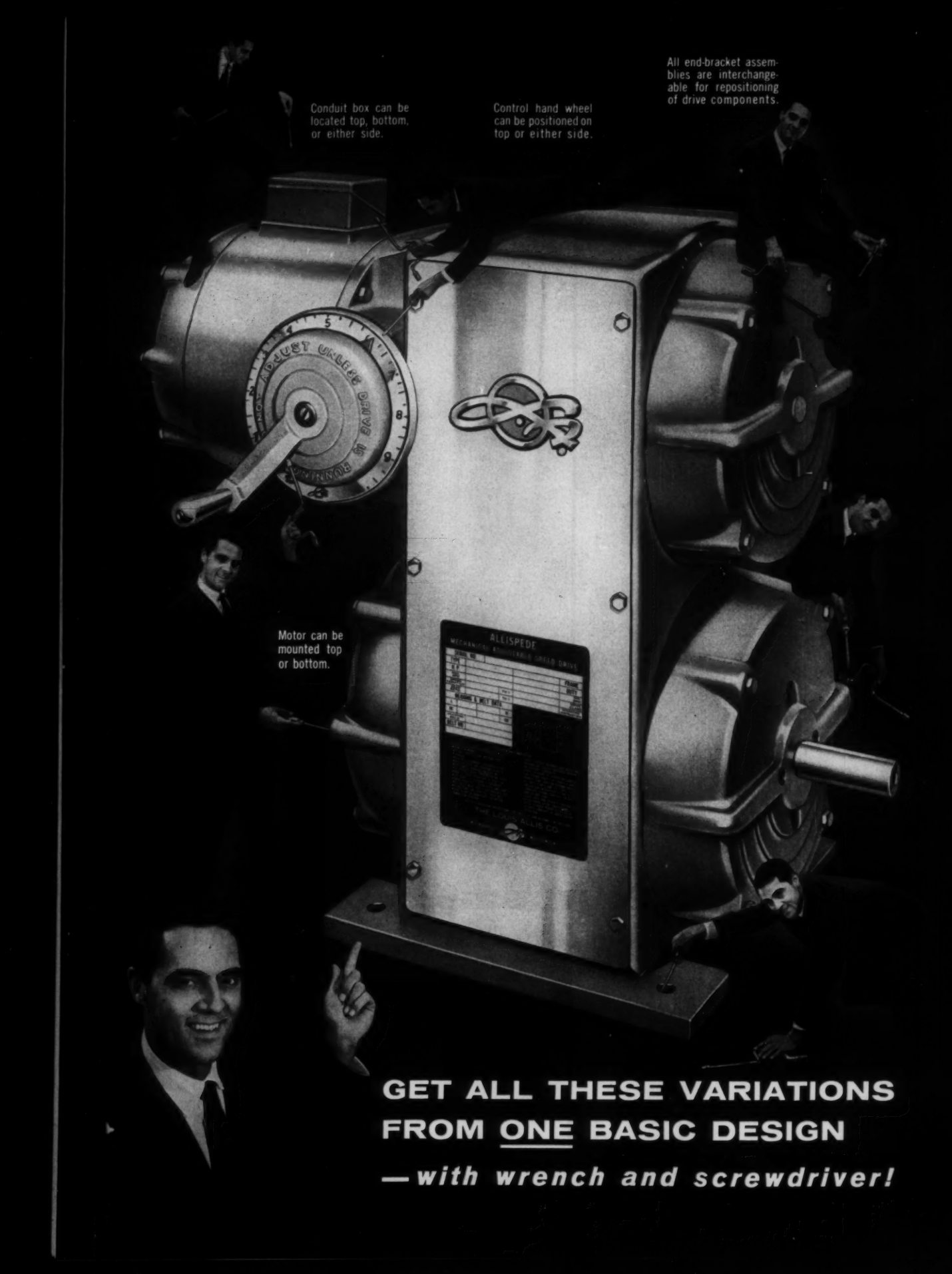
All end-bracket assemblies are interchangeable for repositioning of drive components.
Conduit box can be located top, bottom, or either side.
Control hand wheel can be positioned on top or either side.
Motor can be mounted top or bottom.
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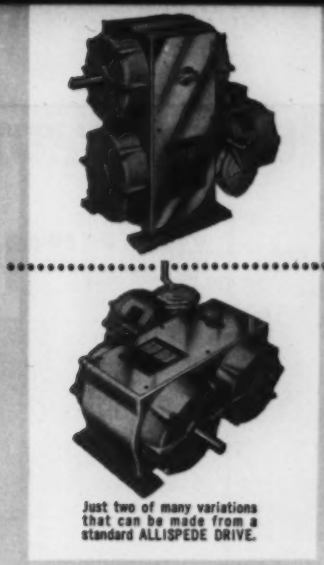
FROM ONE BASIC DESIGN
—with wrench and screwdriver!



Just two of many variations that can be made from a standard ALLISPEDE DRIVE.

Another NEW product from Louis Allis

The ALLISPEDE* DRIVE gives you complete design versatility!

"Building-block" principle, using one basic unit, permits this drive to fit into any design requirement regardless of space or shape limitations!

The *all-new* ALLISPEDE DRIVE is a simple answer to the problem of providing low-cost adjustable speed in a variety of designs. The basic unit goes together like blocks — you pick the assembly you want — locating feet, end brackets, control hand wheel, conduit box, and output shaft to suit the requirements of the driven machine.

Output shaft can be high or low, right or left.

The same unit can be used for horizontal or upright floor, wall, or ceiling mounting — there are no "fixed" components to limit installation. And all of these adjustments are easily made in minutes with just a wrench and screwdriver, right on your assembly floor! As a result, a lower inventory of drives still covers your production requirements.

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Rugged cast-iron housing with plated steel covers shields drive against dirt and corrosion . . . integral rotor fan cools the motor and force-ventilates the drive housing to extend bearing life. Oversize cartridge bearings are pressed on shaft and lubricated at the factory. Corrosion-resistant stainless-steel nameplates diagram proper motor connection, specify bearing sizes, and carry complete instructions for operation and lubrication.

The ALLISPEDE DRIVE can be supplied with in-line or right-angle integral gears, brake, and tachometer. Sizes from 1 to 20 HP, with speed variations up to 8:1. Electrical and mechanical modifications for any application.

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Circle 435 on Page 19

ASD-117

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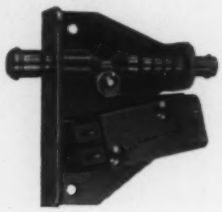
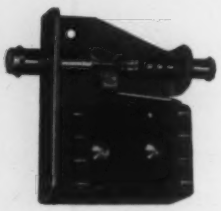
Push to operate;
returns automatically.

Pull to operate;
remains in operating position until reset for automatic return by next full-stroke push operation.

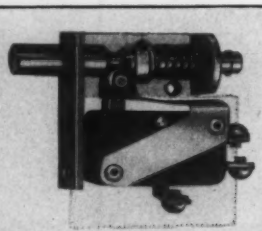


MODEL C2-4 S.P.D.T. 2 ckts. **Elec. rating:** 125/250 V.A.C., 30 V.D.C. —10 amps. 125 V.D.C., ½ amp. 250 V.D.C., ¼ amp. **Oper. force:** 2 lbs. ± 12 oz. **Weight:** 2 oz. **Dimensions:** 1-13/16" x 1-31/32" x 9/16"



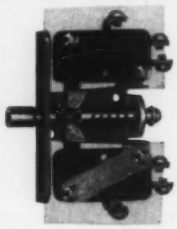
MODEL C2-9 D.P.D.T. **Elec. rating:** 15 amp. 125/250 V.A.C. 60 cycle. **Oper. force:** 4¾ lbs. ± 12 oz. **Amb. temp:** —100° to + 275° F. **Elec. & Mech. Life:** 150,000 ops. **Weight:** 2 oz. approx. **Dimensions:** 1-29/32" x 1-31/32" x 9/16"

MODEL C2-14 T.P.D.T., 6 ckt. **Pre-travel:** 5/32" min. **Overtravel:** ¼" approx. **Mov. Diff.** .028" ± .007" **Elec. rating:** 15 amp. 125/250 V.-A.C.—15 amp. 30 V.D.C., res.—10 amp. 30 V.D.C., ind. **Life**—500,000 ops. min. **Dimensions:** 2-5/16" x 1-31/32" x 9/16"



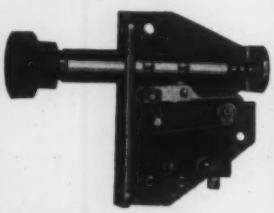
MODEL C2-5 Solid shaft. S.P.D.T. **Elec. rating:** 10 amps. @ 125/250 V.A.C., 60 cycles. **Oper. force:** 2 lbs. ± 12 oz. **Amb. temp.:** —100° to + 275° F. **Elec. & Mech. life:** 150,000 ops. **Weight:** 2 oz. **Dimensions:** 1-13/16" x 1⅞" x ½"

MODEL C2-10 same as C2-5, except has threaded shaft.

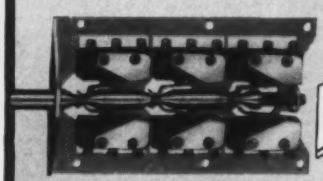


MODEL C2-7 Solid shaft. D.P.D.T. **Pre-travel:** 3/16" max. **Elec. rating:** 10 amp. 125/250 V.A.C. 60 cycle. **Amb. temp.:** —100° to + 275° F. **Elec. & Mech. Life:** 150,000 ops. **Dimensions:** 2-3/32" x 1⅞" x 33/64"

MODEL C2-6 same as C2-7, except has threaded shaft.



MODEL C2-15—Subminiature interlock. S.P.D.T.; **Elec. & Mech. Life and Rating:** 150,000 ops. @ 2.5 Amps., 125/250 V.A.C.; 100,000 ops. @ 5 amps, 125/250 V.A.C. **Dimensions:** 1-13/16" x 1¼" x 9/16". Various colored buttons available.
(Also available in momentary contact, one-way impulse action.)



GANGED INTERLOCKS—2 or more switches may be ganged for multiple control with single actuation.

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3M Adhesive EC-1357 bonds all kinds of skin and core materials *without heat*. You'll speed production, cut costs, build in high strength for non-load-bearing sandwich panels.

You can force-dry the solvent out of the adhesive prior to bonding. And a nip roller or cold press is all that is required to complete the bond.

EC-1357 provides maximum immediate strength. And the bond continues to strengthen as it cures at room temperatures.

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...WHERE RESEARCH IS THE KEY TO TOMORROW

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FROM GENERAL ELECTRIC—A COMPLETE **PLUS LINE** OF LOW-SPEED DRIVES

NOW! Rugged, Compact Power Transmission Products Meet Every Low-speed Drive Need

General Electric offers a complete PLUS LINE of compact power transmission products built to meet all your low-speed drive requirements. Complete PLUS LINE includes: shaft-mounted and separate speed reducers, integral type and all-motor gear motors—each available in a wide range of ratings and configurations for all your applications.

Shaft-mounted Speed Reducers provide speed reduction with maximum flexibility. Directly mounted on the driven shaft, these compact speed reducers eliminate the need for flexible couplings and simplify multiple chain and belt drives. Ratings: ¼- to 40-hp, 420 to 10 rpm; ratios 5:1 to 15:1.

New Helical Speed Reducers are easy to install, especially in confined areas. Uses long-lasting precision helical gears. Can be direct coupled or offset driven by any type of prime mover. Ratings: 1- to 200-hp; ratios 5:1 to 127:1.

New Integral Type Gear Motors eliminate couplings or other devices for connecting motor and reducer. Compact design cuts space needs up to one-third, reduces shipping, installation and handling time. Built-in alignment of motor and gear assures proper installation, easy maintenance. Ratings: 1- to 30-hp; 780 to 13.5 rpm.

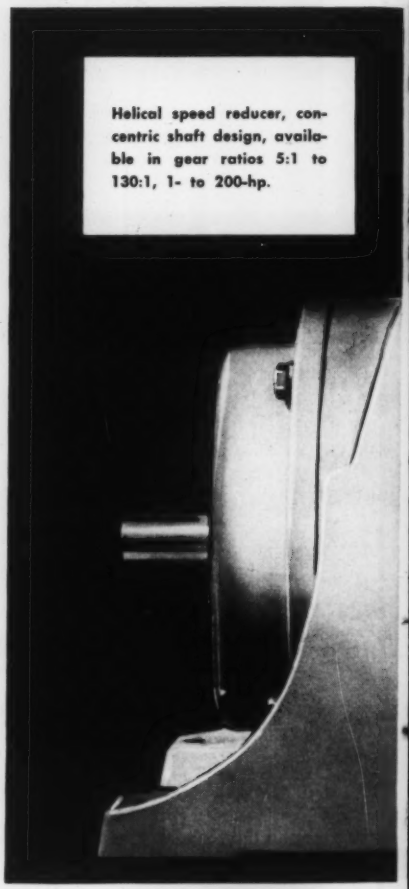
New All-motor Gear Motors increase application flexibility, accommodate any motor type of same frame size and horsepower. Motor replacement is quick and easy—reducer need not be disconnected from driven machine—to keep downtime to a minimum. Ratings: 1- to 75-hp; 520 to 13:5 rpm.

Easy Maintenance. Modern design simplifies inspection and maintenance. Units can be quickly disassembled with standard tools, and components can be replaced in your own shop.

Long Life. Concentric bearing bores assure precision line-up of gears, and larger housing dissipates heat more rapidly for longer lubricant life. Every G-E design is factory and field tested to provide reliable operation, even in the toughest applications.

Reduced Inventories. Immediately available distributor stocks and fast factory shipment enable you to maintain normal operational efficiency with a minimum of parts stock.

For Complete Information contact your nearby G-E Apparatus Sales Office or Distributor, or write for bulletins: G-E Helical Gear Motor Line (GEA-6704), Shaft-mounted Speed Reducers (GEA-6616), Fractional Horsepower Gear Motors (GEA-6133A), Section 851-8, General Electric Co., Schenectady, N. Y.



Helical speed reducer, concentric shaft design, available in gear ratios 5:1 to 130:1, 1- to 200-hp.

Right angle shaft gear motor

CHOOSE FROM

GENERAL ELECTRIC

When Deciding on Power Transmission Equipment, Consider All These **PLUS VALUES** You Get by Specifying General Electric Gear Motors and Speed Reducers

Product Application Service—Experienced G-E engineers at all field sales offices and the Gear Motor and Transmission Components Dept. are available to help analyze your installation needs.

Product Design Assistance—General Electric offers custom-designed or modified standard gear motors and speed reducers built to your specifications.

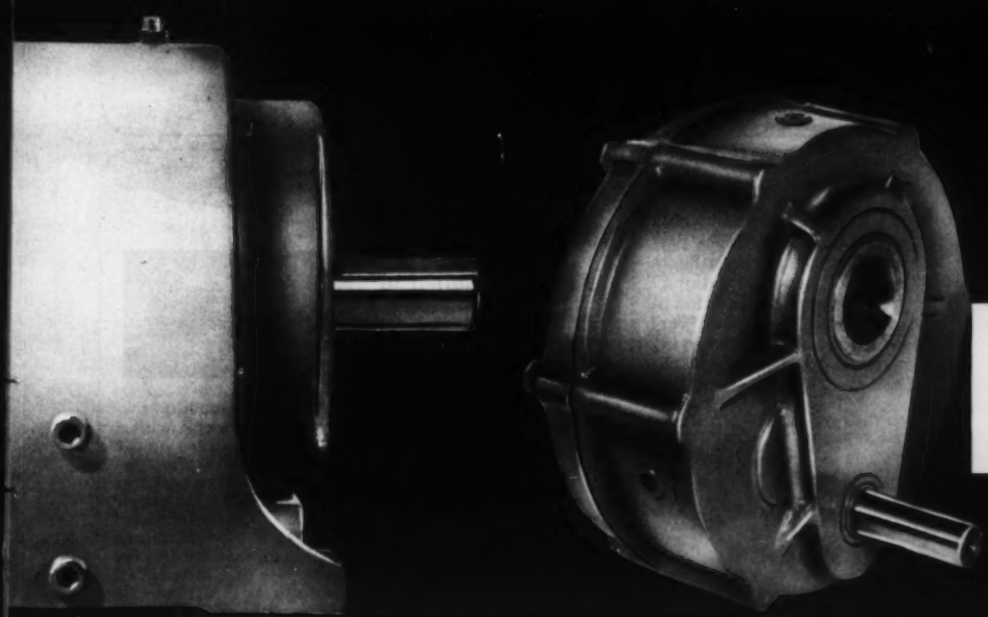
Immediate Shipment—Standard units are factory- and distributor-stocked for rapid shipment to all points. G-E engineering teams using modern plant facilities help meet tight shipment schedules on custom-built units.

Sales Service—Your inquiries, quotations and requests for bids are handled promptly by one of the many General Electric field sales offices.

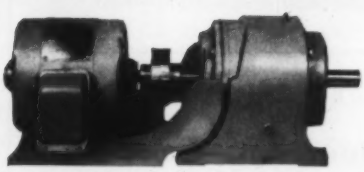
After Sales Service—50 General Electric Service Shops and 500 authorized Small Motor Service Stations offer expert repair service on all G-E Gear Motor products.

Broad Product Line—You select the equipment you need from the industry's most complete line. G.E. also focuses manufacturing responsibility at *one* source, for it produces *all* gearing, components and motors included in its line.

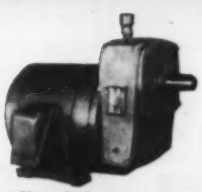
Manufacturer Reputation—Advanced technology built into G-E power transmission equipment helps it exceed strict AGMA standards, adds value to and builds preference for your product.



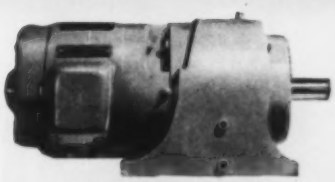
Shaft-mounted speed reducer for direct mounting on driven shaft, ¼- to 40-hp, with possible output speed range 420 to 10 rpm.



All-motor gear motor



Offset-shaft gear motor

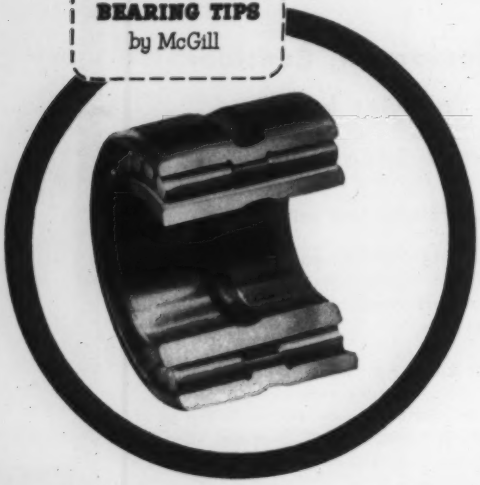


Integral-type gear motor

GENERAL ELECTRIC'S **PLUS LINE** OF POWER TRANSMISSION EQUIPMENT

Circle 438 on Page 19

BEARING TIPS
by McGill



GUIDEROL® needle roller bearings save space and simplify design

. . . especially where their greater capacity can reduce the size and cost of an adequate bearing housing. More and more designers are specifying McGill GUIDEROL bearings to carry heavier loads dependably with smaller bearings.

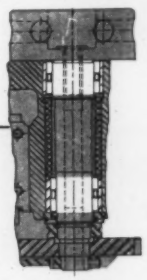
GUIDEROL bearings combine full type bearing capacity with center guided rollers that limit skewing and eliminate the possibility of binding under average misalignment. Especially suited to vertical mounting.

These precision heavy duty needle roller bearings are available with or without inner races in shaft sizes from ⅜" to 9¼". Specify the sealed series to keep out contamination and avoid relubrication.

Minimum clearance, maximum load capacity retained in automatic screw machine

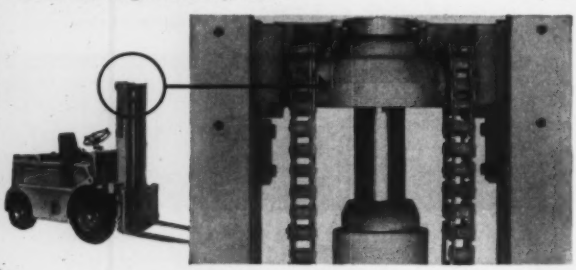
BROWN & SHARPE MFG. CO. replaced plain scraped bushings in the turrets of their No. 00 Automatic Screw Machines with McGill GUIDEROL bearings.

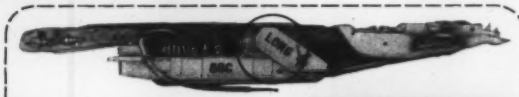
GUIDEROL bearings were selected to retain minimum clearance and maximum load capacity. In addition to meeting these requirements, the GUIDEROL eliminated production problems involved in the use of the scraped tapered bushings. The bearings support the turret during cutting and indexing operations. GUIDEROL design also satisfies the need for maintaining accurate alignment throughout long machine life.



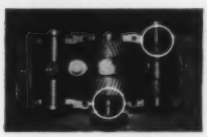
High capacity and compactness in lift truck chain cross-head rollers

GUIDEROL bearings support TOWMOTOR 6000 through 11,000 pound capacity lift truck payloads. They are used as chain crosshead roller bearings. Space requirements and the need for high capacity without the "walking" tendency of a straight needle roller bearing led to the selection of GUIDEROL bearings. GUIDEROL bearings have been rated very well in terms of length of life, maintenance and load carrying capacity in this application. Performance is rated excellent. The user reports reduced service requirements as compared with straight needle bearings formerly used.





Design simplified in mine machine transmission



Manufactured by the LONG Company, "PIGLOADER" coal loading machines feature full independent crawler control with a single motor. Application of GUIDEROL bearings on the tram clutch shaft is typical of other McGill bearing applications on the loader. GUIDEROL CT series bearings are used on the output end of the shaft to handle purely radial loads in small radial space. On the opposite end of the shaft, double row ball bearings handle combined thrust and radial loads. This combination eliminates the need for complicated adjustments. Use of a roller bearing, which has the same dimensions as the thrust bearing, accomplishes the design purpose with minimum machining variation in the transmission case. The GUIDEROL equipped tram transmissions allow each crawler to operate independently, a substantial design improvement.

engineered electrical products

McGILL®

precision needle roller bearings

SEND FOR CATALOG No. 52-A

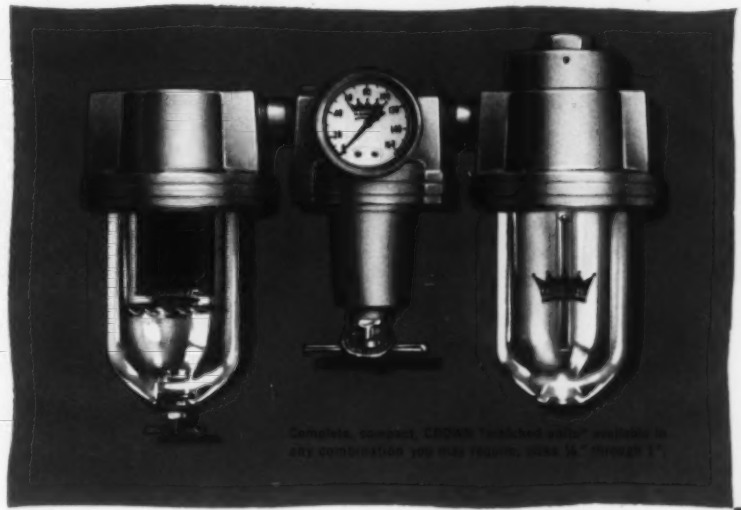
MULTIROL — GUIDEROL — CAMROL

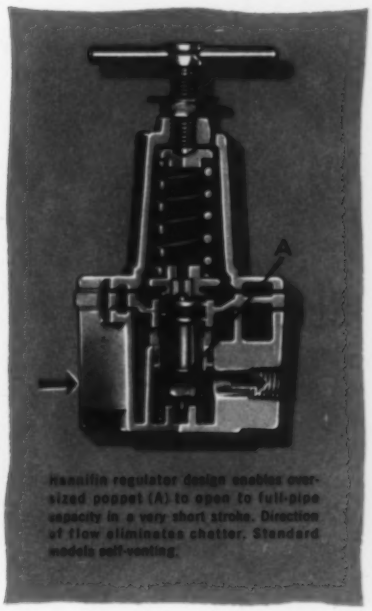
McGILL MANUFACTURING COMPANY, INC., BEARING DIV., 200 N. LAFAYETTE ST., VALPARAISO, INDIANA

Circle 439 on Page 19

Circle 440 on Page 19 for Fittings→

Crown From HANNIFIN air preparation units that don't waste air power





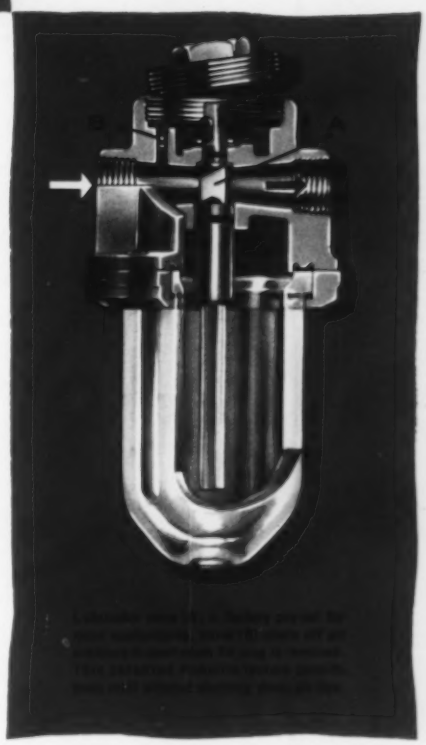
Hannifin regulator design enables oversized poppet (A) to open to full-pipe capacity in a very short stroke. Direction of flow eliminates chatter. Standard models self-venting.

Hannifin CROWN "Combo" units – filters, regulators and lubricators in any combination – keep compressed air in the "pink of condition" without depriving you of needed air flow.

Crown regulators open fast on demand, close precisely when demand is satisfied, deliver the exact amount of air needed. Their "piston balanced" poppet design, which makes possible a flat, large-area, poppet-type valve with very short stroke, is the reason. The inherent stability of this design – no hunting or chatter – results in multi-million cycle life.

Crown filters have large, reusable filter elements for minimum resistance to air flow. Crown lubricators introduce predetermined amounts of oil into the air stream, automatically. Their design is so responsive to variations in air flow rate that the concealed, tamperproof adjustment is rarely used. This is the easiest lubricator of all to fill, and remote-fill models are available.

Crown units are competitively priced and stocked in principal industrial areas by Hannifin CROWN authorized distributors. For CROWN literature and the name of the distributor nearest you, write:



HANNIFIN COMPANY

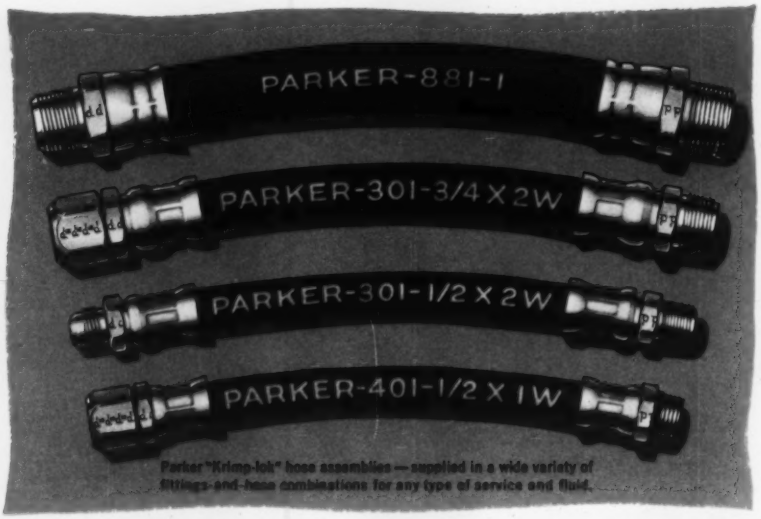
535 South Wolf Road • Des Plaines, Illinois

Now from Parker

BOTH permanent-end

and re-usable

hose assemblies



Parker "Krimp-lok" hose assemblies — supplied in a wide variety of fittings-and-hose combinations for any type of service and fluid.

You may require permanent-end hose assemblies for your production AND re-usable fittings with coils of hose for quick, trouble-proof replacements in the field. With the addition of Parker's new "Krimp-lok" fittings, permanent-end assemblies are now available from Parker. They use the same Parker hoses that enjoy a wide acceptance when used with Parker *no-skive* "Hoze-lok" fittings in the replacement field.

A full range of Parker adapters is also available.

Ask your Parker Hose Distributor, listed in the Yellow Pages, for engineering advice and literature on "Hoze-lok" re-usable fittings, also Parker hose and adapters. Write us in Cleveland regarding your requirements for Parker "Krimp-lok" Hose Assemblies.

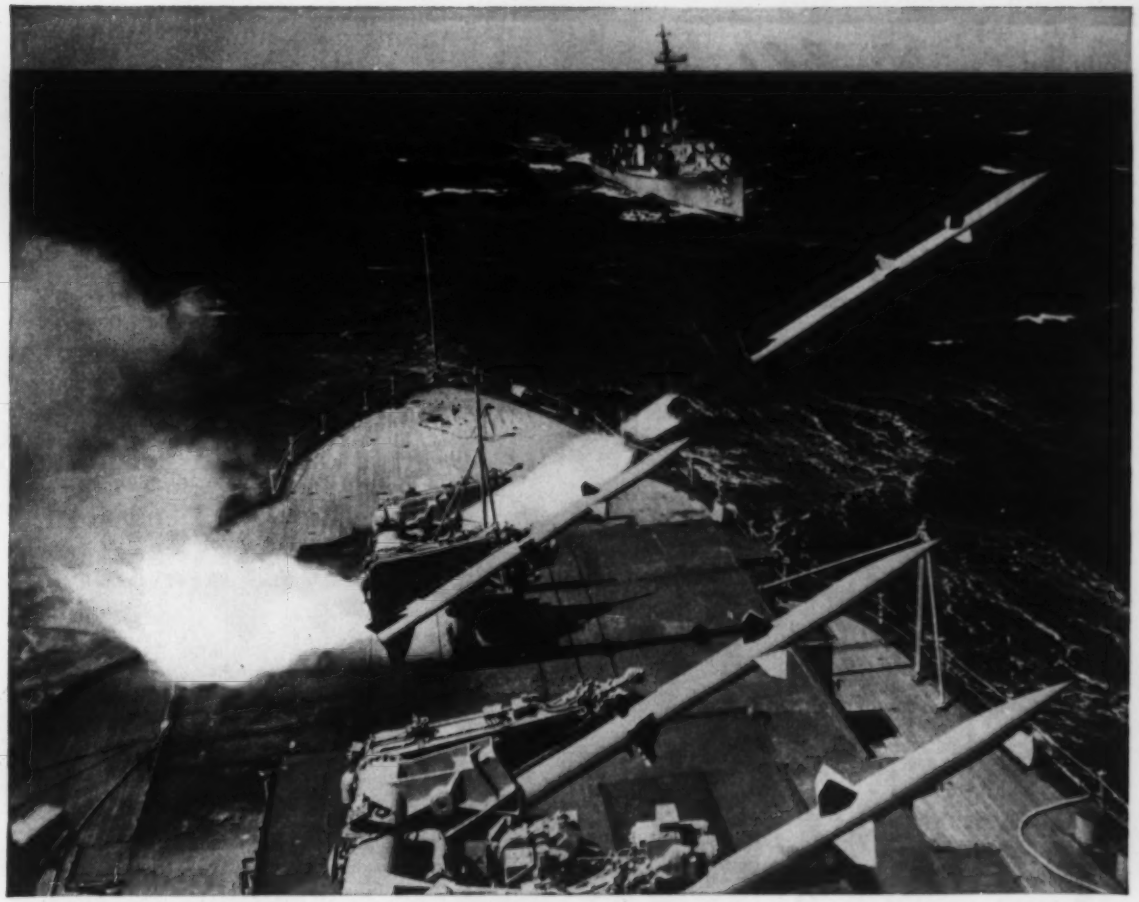
Parker

FITTINGS AND HOSE

DIVISION

17325 Euclid Avenue

Cleveland 12, Ohio



LAUNCHING AT SEA. Unarmed as it roars skyward, the Terrier guided missile is armed in the air by action of "heavy metal" counterweights. Most "heavy metals" contain 6-7% Nickel. *Official U. S. Navy photograph.*

How the Terrier "unmuzzles" itself

The Navy's Terrier guided missile is "muzzled" as it streaks from its launching vessel into the sky. A safety mechanism keeps the missile from exploding prematurely even under severe shock conditions.

Cocking action is automatic. At a minimum safe distance from the deck, the force of acceleration depresses spring-loaded weights. Their movement cocks the missile.

The weights are made of Fansteel 77* metal, one of a group of high-density tungsten alloys containing Nickel and copper which are described by the simple but expressive term, heavy metal.

Heavy metal packs a lot of weight into a little space. It weighs half again as much as lead, yet is stronger than structural steel.

Tungsten is heavy by itself, of course, but is relatively difficult to shape. By combining it with Nickel by powder metallurgy, the Nickel and tungsten powders can be formed into shapes that require very little further finishing.

Many other uses. In addition to the partnership of *weight* and *workability*, heavy metal offers another desirable combination: *good corrosion resistance* and *moderate cost*. This foursome is responsible for bringing heavy metal more and more jobs daily – jobs ranging from electrical and electronic parts to radiation shielding and vibration damping.

Do you have a metal problem weighing you down? Perhaps one that involves corrosion . . . high or low temperatures . . . stress . . . fatigue . . . or other troublesome service conditions? Talk it over with us. Nickel alloys offer many unusual properties, and can very likely prove useful in lightening your burden.

*Registered trademark of Fansteel Metallurgical Corp.

The International Nickel Company, Inc.
67 Wall Street New York 5, N.Y.

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

←Circle 441 on Page 19 for Air Preparation Units

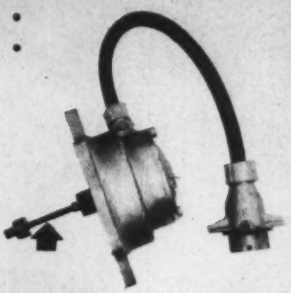
S.S.White

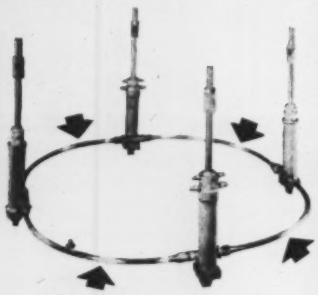
DRIVE AND CONTROL IDEAS FOR ENGINEERS

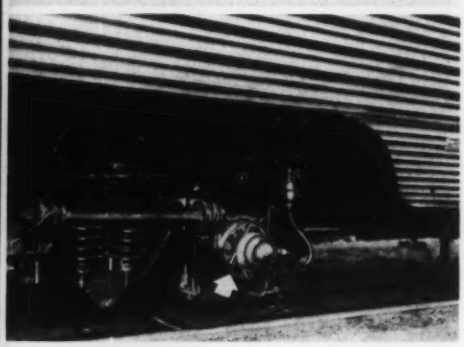
Tips on better designing with flexible shafts

REMOTE CONTROL

Reliable synchronization at high temperature is made possible by S. S. White flexible shafts on this actuator system for jet afterburner nozzles. The job assigned the shafts was to synchronize the system to permit multipoint installation and smooth, even application of power . . . at ambient temperatures up to 650F! To see how flexible shafts simplify design, picture doing this with solid shafts, gearing, universals, and other paraphernalia, around a 360° bend . . . and then imagine installing it!







POWER DRIVE

Running cool at 45,000 rpm! The S. S. White flexible shaft on this grinder-miller permits the use of carbide and diamond tools at speeds that were previously unknown to hand tools. The flexible shaft drives the handpiece from a ¼-hp motor suspended over the table at speeds up 45,000 rpm, without overheating and without vibration. A good point for designers to note is that in many cases, the higher the speed of a flexible shaft, the better the performance.

COUPLING

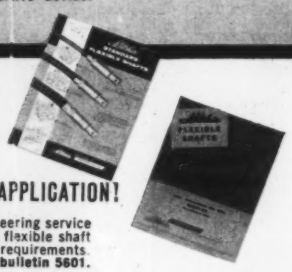
Alignment and vibration problems are solved by an S. S. White flexible shaft on this railroad brake controller. The device detects wheel slippage during braking, by means of rotary switches on each axle that detect changes in relative movement between pairs of wheels on the truck. If damaging slip occurs, the device releases brake pressure until slippage stops. A flexible shaft is fitted to the axle and drives the rotor in the switch, eliminating alignment problems and preventing excessive axle vibration from reaching the sensitive device.

S.S.White

FIRST NAME IN FLEXIBLE SHAFTS

S. S. WHITE INDUSTRIAL DIVISION (Dept. 4)
10 East 40th Street, New York 16, N. Y.
Western Office: 1839 West Pico Blvd., Los Angeles, Calif.

1094



Standard S. S. White flexible shafts are available "off the shelf," making many savings possible.
Write for bulletin 5801.

USEFUL DATA ON SELECTION and APPLICATION!

S. S. White also offers engineering service and comprehensive selection of flexible shaft sizes and types to meet special requirements.
Write for bulletin 5601.

FAR LESS STRESS IN LXS

THE CHAIN WITH NO "STRESS RAISERS"!
Link-Belt LXS brings long-term economy and efficiency to the most punishing drive and conveying jobs. With its "FULL-ROUND" design, LXS has no stress concentration points . . . none of the sharp corners which frequently shorten the life of many ordinary chains.

LXS is available with straight or offset sidebars. For details, contact your nearest Link-Belt office. (See CHAINS in the yellow pages of your phone book.) Ask for our new, comprehensive Catalog 1050.

They're all of "FULL-ROUND" design

PINS BUSHINGS SIDEBARS

"FULL-ROUND" design eliminates traditional stress concentration points in Link-Belt LXS . . . provides maximum live bearing area between pins and bushings. Result: stress is distributed evenly.

Other LXS long-life features include controlled press fits plus use of selected steels and controlled hardening of all parts. All this contributes to greater uniformity, greater endurance.

LINK-BELT

CHAINS AND SPROCKETS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 15,062

Auto Maker Switches to New Thomas Strip Pattern Rolled Steel for Instrument Panels

All four sections of instrument panel are tested for dimensions in checking fixture in Quality Standards Department of auto plant.

Rolled-in Calf-Skin design withstands deep draws, takes paint well.

Instrument panels fabricated from Pattern Rolled Strip Steel made their debut in all 1959 models of one of the largest auto makers.

The Pattern Rolled Steel Strip is furnished the auto maker by the Thomas Strip Division of Pittsburgh Steel Co. with a leather grain. Pattern Rolled, in any design that can be drawn with pencil and paper, is available in strip and sheet widths up to 48 inches.

The auto manufacturer specifies Pattern Rolled in five widths ranging from 16 to 23½ inches in coils of steel measuring .041 inch in thickness.

• **Made In Sections**—Presses with up to 70,000 pounds pressure fabricate the instrument panels in four sections—upper right and left and two side panels. After painting and baking, panels are assembled in car bodies on the assembly lines. Testing

Close-up of the calf-skin grain rolled into the steel at Pittsburgh Steel Co.'s Thomas Strip Division.

In fabricating unit of large auto manufacturer, an instrument panel section is examined in checking fixture.

Instrument panel sections are painted and then assembled in the completed auto body.

on checking fixtures assures that both individual sections and complete panel assemblies are accurate dimensionally for a smooth fit during assembly.

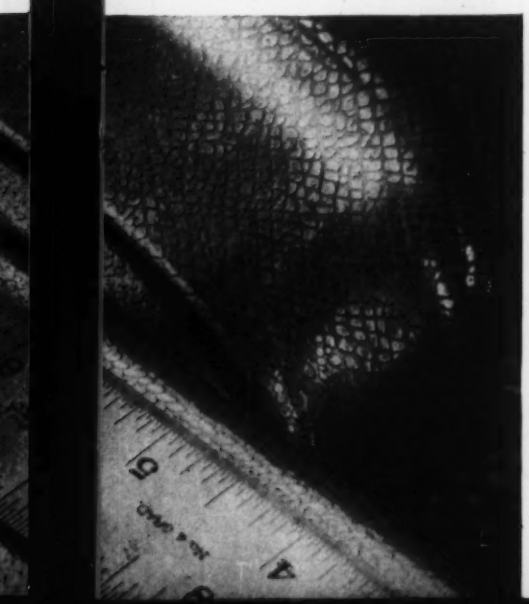
Uniformity of hardness is another prime requirement for steady pressing operations. Surface is critical, too, because flaws would spoil the leather appearance and show through the painting job. Surface quality also plays a part in providing good adhesion between steel and paint.

Drawing quality must be tops. On the upper left instrument panel section, a corner is drawn to a depth of 4½ inches without tearing the steel or even pulling the design out of alignment. Here a correction of .001 inch in the depth of the original pattern yielded the best results. Now Thomas Strip provides coils pattern rolled to a very rigid specification on depth of pattern.

Pattern Rolled Thomas Strip is made from cold rolled steel with all the skill which Thomas has built up in more than 40 years of strip experience. Now Pattern Rolled is available in sheet widths with any pattern you desire rolled into the steel from one edge to the other and from the start of the coil right to the end.

Any fabricator whose product can gain sales appeal from improved appearance will profit by investigating the advantages of Thomas Strip's Pattern Rolled Strip or Sheet. It's available plain, or coated, in many widths with copper, brass, tin, chrome, nickel, zinc or lead alloy. Thomas Strip Pattern Rolled also can be coated with paint, enamel or lacquer on both sides or even on each side in a different color.

Whether you choose a design for product appearance or as an aid to further processing, Pattern Rolled's drawing quality, formability and surface will bring you production economies. Consult a Thomas Strip engineer on how you can use this new, modern metal. Call a Thomas man in the nearest district office.



Thomas Strip® Division

Pittsburgh Steel Company

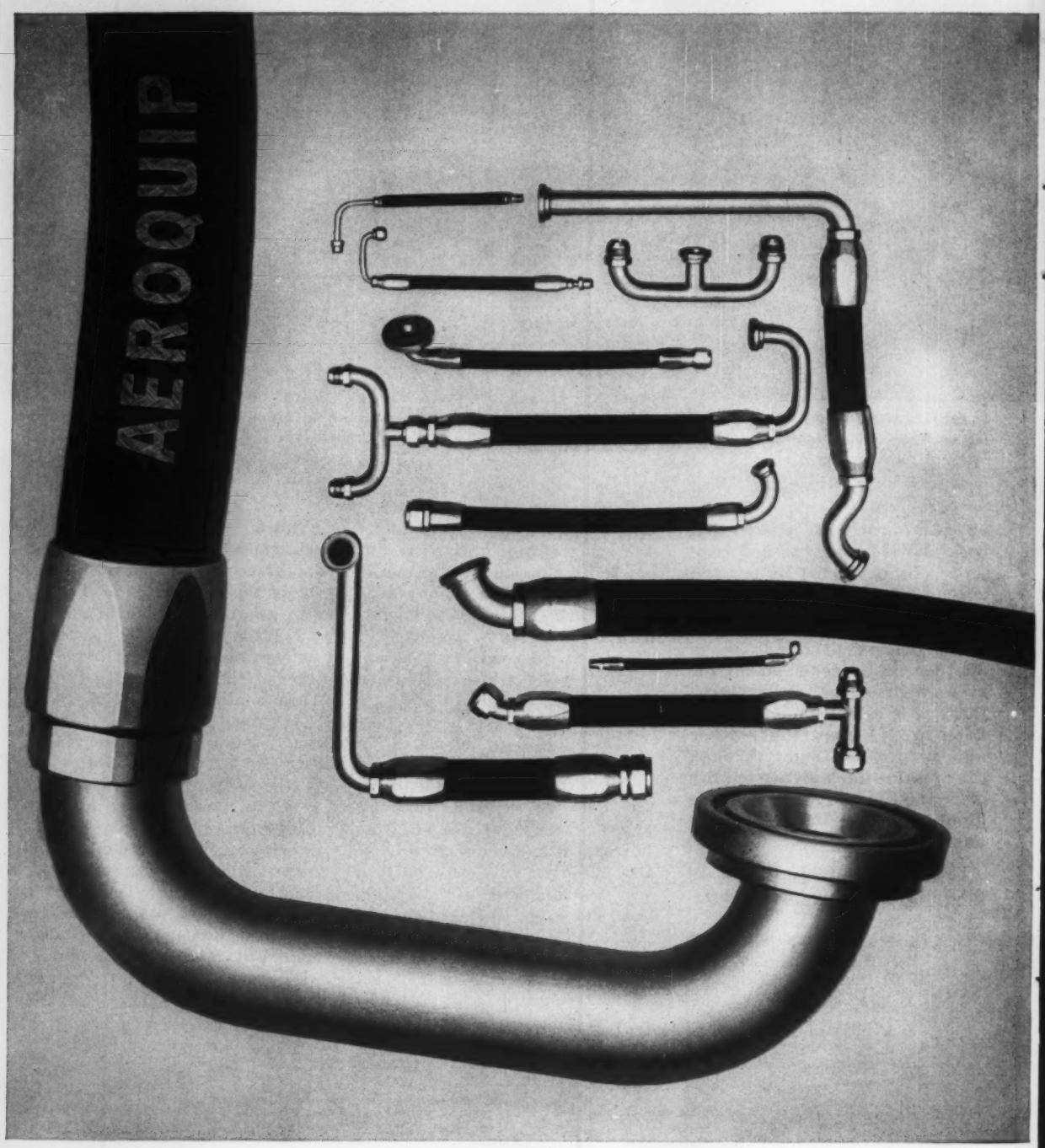
Grant Building • Pittsburgh 30, Pennsylvania

DISTRICT SALES OFFICES

Atlanta	Cleveland	Detroit	Los Angeles	Pittsburgh
Chicago	Dayton	Houston	New York	Tulsa
			Philadelphia	Warren, Ohio

Circle 443 on Page 19

Now Aeroquip Offers a New Concept of Fluid



See Aeroquip Products On Display At The Design Engineering Show

Booths 1132, 1134, 1136

Philadelphia, May 25-28

Shown above are examples of Aeroquip Fluid Piping Assemblies designed and produced for manufacturers. Note the variety of configurations with special brazed hose fittings in split flange, J.I.C., S.A.E., P.T.T. and P.T.F. threads. Hose types include 2556 Cotton Braid Hose, 2651 and 1534 Single Wire Braid Hose, 1509 Double Wire Braid Hose and 1508 Spiral Wire Wrap High Pressure Hose. Special formed tube fittings are of steel, stainless steel and aluminum. Other tubing materials and hose types are available.

Aeroquip Fluid Piping Assemblies like these can decrease the required number of components, producing a highly simplified and trouble-free fluid system on the equipment you design and build.

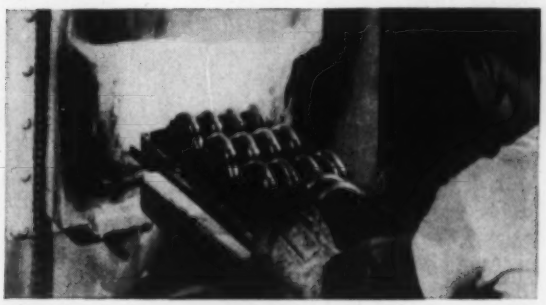
Piping Service for Manufacturers

Complete Product Lines, Unmatched Facilities, Plus Unique Follow-Through Simplify Fluid Piping Problems on All Equipment

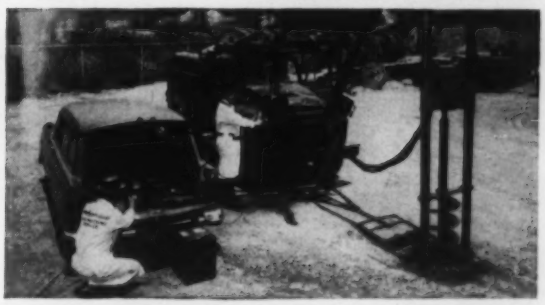
- DESIGN
- PROTOTYPE
- PRODUCTION
- FIELD SERVICE
- SERVICE PARTS

DESIGN Do as scores of leading manufacturers have done: put your fluid system design problems in the hands of Aeroquip's skilled specialists.

PROTOTYPE Aeroquip's new development engineering center can furnish mockups of products and systems you need, tested under conditions encountered in actual operation.



PRODUCTION Flexible hose with reusable fittings and special configuration tube fittings can be produced to your volume requirements, shipped in bulk or as complete assemblies.



FIELD SERVICE Special Aeroquip-developed test equipment plus trained field personnel can assist you in improving the field service life of your equipment.

Aeroquip offers you complete service in solving fluid piping problems on the equipment you build. Highly qualified Aeroquip sales and service engineers with years of experience in this field are available to work with you at your headquarters on design, building prototypes, assisting in production problems, service in the field, and in your service parts program. A full line of all types of hose, special and regular fittings, and unequaled engineering and manufacturing facilities are available for you in producing the type of piping that will solve any specific problem. Aeroquip also forecasts industry requirements and maintains large stocks of all items, and is able to supply prompt shipment whether your requirements are for 1 or 1000 pieces.

These are the reasons why Aeroquip accepts responsibility for fluid piping performance, even to furnishing after-sales service in the field to a unique extent. Get complete information by returning the coupon below.

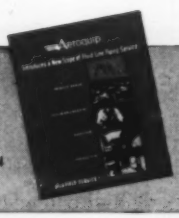
Aeroquip

REG. TRADEMARK

AEROQUIP CORPORATION, JACKSON, MICHIGAN

INDUSTRIAL DIVISION, VAN WERT, OHIO • WESTERN DIVISION, BURBANK, CALIFORNIA
AEROQUIP (CANADA) LTD., TORONTO 19, ONTARIO

AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U.S.A. AND ABROAD



MD-4

Special Literature Available

Aeroquip Corporation, Jackson, Michigan

- ☐ Please send me a copy of Bulletin 614 explaining your complete service of fluid system design and performance.
- ☐ Please have an Aeroquip Sales Engineer call on me to discuss this service.

Name_____

Title_____

Company_____

Address_____

City_____ Zone____ State_____

Circle 444 on Page 19

finest quality!

Precision "O" Ring quality is maintained by over 100 inspections and quality control tests. As a final step, "O" Rings are rigidly inspected to assure "O" Rings that are:

1. Free of flash. 2. True to size. 3. Meet the specifications.

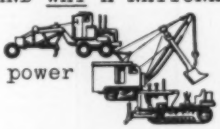
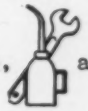
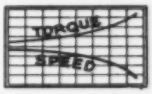
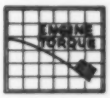
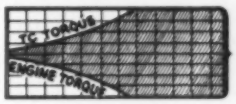
Have a sealing problem? You'll find the answer at Precision. There's a Precision engineer ready to help you with "O" ring specification and with product design.

Specify Precision—first in quality

Precision Rubber Products Corporation

"O" Ring and Dyna-seal Specialists

Box 431, Oakridge Drive, Dayton 7, Ohio **Canadian plant at: Ste. Therese de Blainville, Quebec**

HERE'S HOW AND WHY A NATIONAL TORQUE CONVERTER on your heavy equipment can give you more usable power  from your engines, reduce excessive maintenance,  and increase machinery life. When equipment driven by a direct-connected engine is overloaded engine speed drops. So does the "Torque" which is the turning-force delivered by crank-shaft. If the overload continues, the engine stalls and its torque drops to zero. When equipment driven through a NATIONAL TORQUE CONVERTER is overloaded, it cannot stall the engine! Engine speed and engine torque both "level-off" in their most efficient zones, and stay there! The torque-converter shaft slows down but at the same time its torque increases! If equipment overload increases, the converter output shaft finally stalls, but at this point it is delivering maximum torque.  Now if you put the diagram showing how engine torque drops  under equipment overload, with the diagram showing how torque converter torque increases under the same overload, you'll see between the two a  "bonus-power" zone of extra usable power that the NATIONAL TORQUE CONVERTER gives you. Power that makes an oversize engine or "babying" of equipment unnecessary. Furthermore, shocks and strains that batter and age equipment are absorbed in the converter. Machinery lasts longer with less maintenance. If YOU own or operate heavy equipment (with 100 to 1000 hp drives) ask for performance records and recommendations.

THE NATIONAL SUPPLY COMPANY

Subsidiary of Armco Steel Corporation

TWO GATEWAY CENTER, PITTSBURGH, PA.

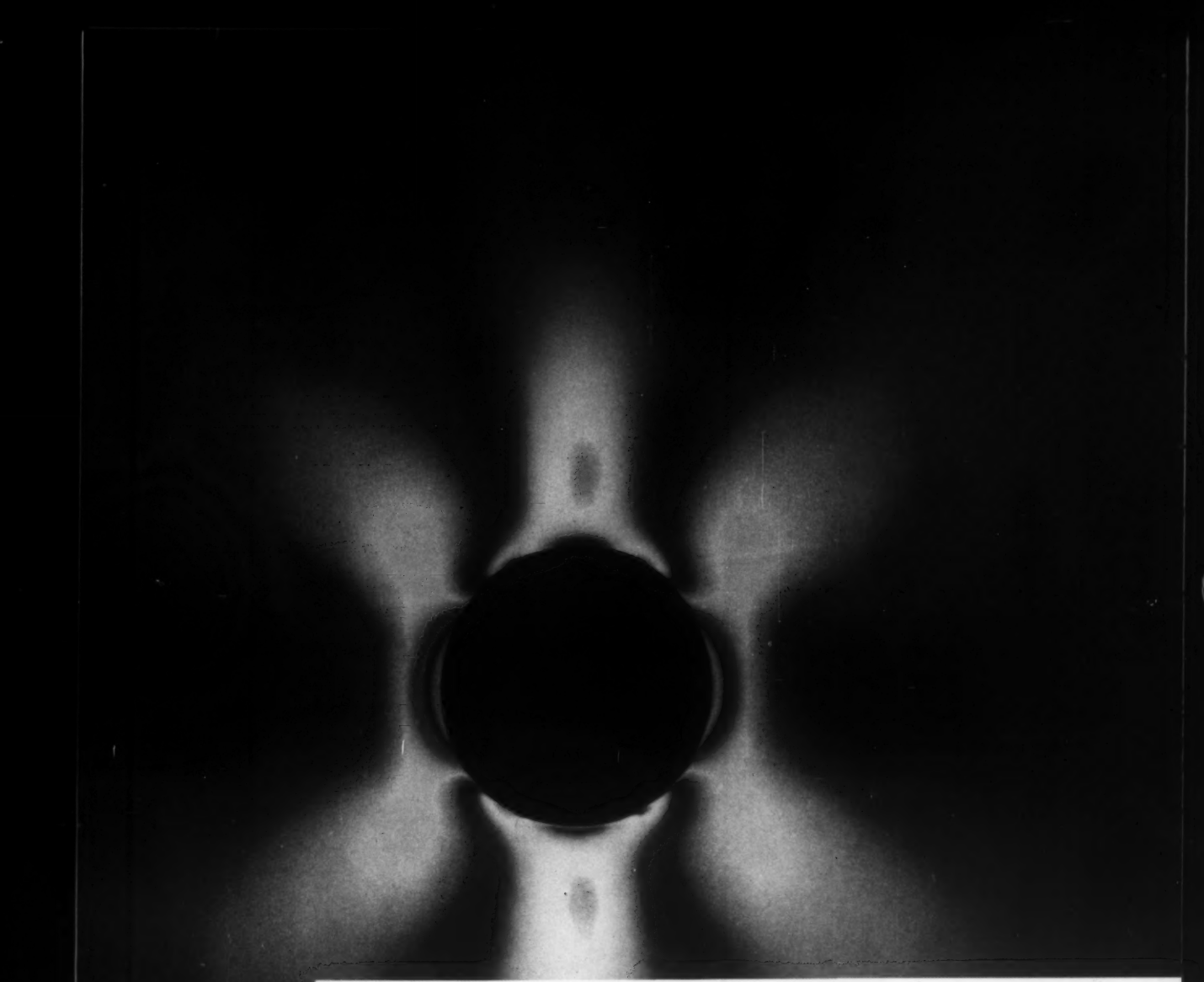


Photo-elastic stress patterns produced by models photographed with polarized light are one of the modern analytic tools available for ever-increasing perfection of Malleable iron castings.

Strength is Malleable

The strength crucial in spiraling the heave of diesels' pistons into unresistible power, in protecting lives as automobiles hurtle down endless highways, and in every link of chain that swings massive loads overhead, is yours to mold into tomorrow's dynamic engineering achievements with Malleable iron castings. Yet Malleable provides this strength in combination with toughness, producibility and economy that makes Malleable castings the finest, most versatile metal available.

For information or service, call on one of the progressive firms that identify themselves with this symbol—

MEMBER
MALLEABLE
CASTINGS COUNCIL

If you wish, you may inquire direct to the Malleable Castings Council, 1800 Union Commerce Building, Cleveland 14, Ohio, for information.

These companies are members of the

MALLEABLE CASTINGS COUNCIL

CONNECTICUT
Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4

DELAWARE
Eastern Malleable Iron Co., Wilmington 99

ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA
Link-Belt Company, Indianapolis 6
Muncie Malleable Foundry Co., Muncie
Terre Haute Mall. & Mfg. Corp., Terre Haute

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA
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Laconia Malleable Iron Co., Laconia

NEW JERSEY
Meeker Foundry Company, Newark 4

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Canton Malleable Iron Co., Canton 5
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6

PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS
Texas Foundries, Inc., Lufkin

WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Badger Malleable & Mfg. Co., S. Milwaukee
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

How to Get More Strength Per Dollar with Malleable Castings

With few exceptions, strength is the most important single design requirement for a metal part. But in the commercial production of that part, the ultimate objective is to manufacture it at the lowest possible cost. Malleable iron castings take advantage of many factors to provide the greatest strength per dollar of any ferrous or non-ferrous metal.

Great Strength Range Available

From the wide range of standard (ferritic) and pearlitic Malleable irons available, a type may be selected that meets strength requirements ranging from 50,000 p. s. i. to 120,000 p. s. i. tensile.

Table No. 1 shows these strength values and other physical measures for 9 grades of Malleable. Note particularly how high yield strengths are in comparison to tensile strengths. Because yield strength is generally the measure of usable strength, this is especially important.

Also important is the uniformity of Malleable's strength. The heat treatment given all Malleable castings produces a unique metallurgical combination of strength, ductility, machinability and impact resistance. At the same time, it relieves internal stresses so that Malleable's strength cannot be machined away, nor will it be present in some parts but missing in others.

TABLE No. 1
TENSILE PROPERTIES—
A.S.T.M. MINIMUM SPECIFICATIONS

Standard and Pearlitic Malleable Irons

Designation	Tensile Strength p. s. i.	Yield Strength p. s. i.	Ratio of Tensile to Yield %
Standard			
35018	53,000	35,000	66
32510	50,000	32,500	65
Pearlitic			
45010	65,000	45,000	69
45007	68,000	45,000	66
48004	70,000	48,000	69
50007	75,000	50,000	67
53004	80,000	53,000	66
60003	80,000	60,000	75
80002	100,000	80,000	80

Strengths up to 135,000 p.s.i. tensile and 110,000 p.s.i. yield are produced commercially under individual producers' specifications.

Economy Due to Multiple Factors

Malleable's superior strength-cost ratio is due to a combination of the casting process, which puts the metal where you want it, and the inherent economy of Malleable iron. Also, whenever machining operations are involved, Malleable castings cut finished costs significantly. Being the most easily machined of all ferrous metals of similar hardness, the cost of the finished part can often be reduced to less than that of metals which cost less in the semi-finished stage.

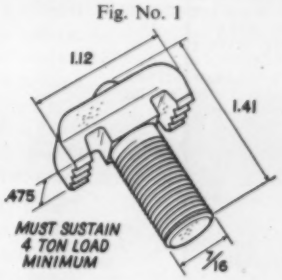
Malleable Provides Strength Plus Other Advantages

The T-bolt shown in Fig. 1 is used to assemble steel channel frames. Small but mighty, these 7/16″ bolts hold 4 ton loads. The tensile strength requirements are 90,000 to 100,000 p. s. i., yet ductility must be good and tolerances must be held to ±.005″ on the head width, and +.020″, −.000″ on the inside of the head.

In this application, pearlitic Malleable castings proved the only material consistently capable of sustaining loads over 8,000 pounds and meeting close tolerances in critical areas. At the same time, sufficient ductility was maintained to allow upsetting the spring retainer protrusion on the head.

The finished Malleable castings cost one third less than the next most satisfactory material. For both dynamic and static applications, today's Malleable castings are truly one of industry's finest engineering materials.

Fig. No. 1



Write for Free Data Unit

Data Unit 102-Strength, more fully describing Malleable's strength characteristics, is available for use by materials specifiers and users. For your copy, contact any member of the Malleable Castings Council or write to Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

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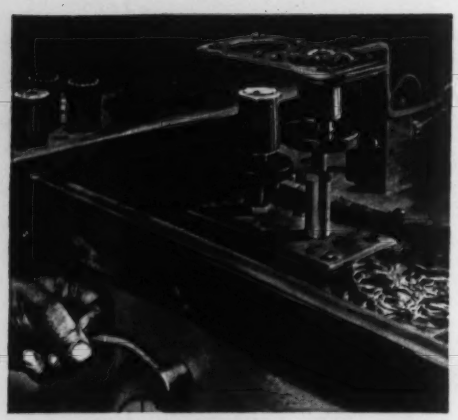
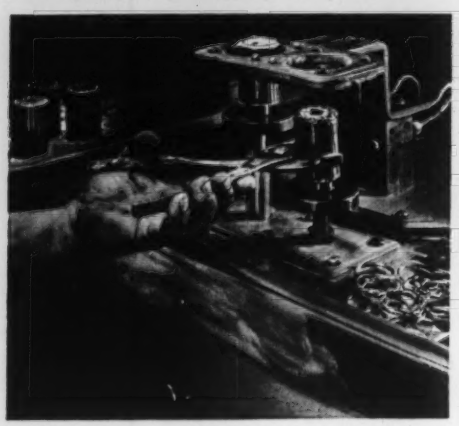
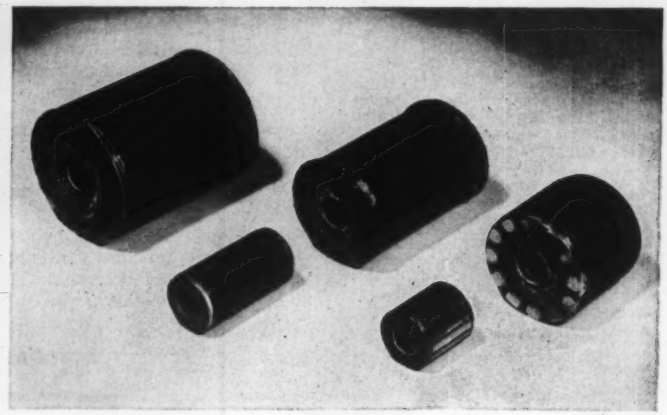


Handy & Harman Sil-Fos Silver Brazing is Used by Induction Motors Corp. in 5427 Different Motors





FIRST, BULLETIN 20

This informative booklet will get you off to a good start on the values, techniques and economies of low-temperature silver brazing. A copy awaits your request.

Induction Motors Corp. of Westbury, New York, and Maywood, California, has built an outstanding reputation as a designer and manufacturer of sub-fractional horsepower motors...for 5427 high performance reasons.

This large variety of motors, blowers and fans for an equally large variety of applications, stems from 15 basic motor frame sizes, depending on length, pole materials, windings, groove angles and the like.

Handy & Harman silver alloy brazing is concerned with brazing the rotors. Each rotor (whatever the size) is joined by a preformed ring of Handy & Harman SIL-FOS, by induction heating – at an alloy cost that is reckoned in pennies. For example, the alloy cost per ⅞" frame is two cents per joint, or four cents per complete assembly.

That's an example of the economics of silver alloy brazing. Performance requirements are quite another thing – and they are unquestionably stringent. Many of these motors are used in aircraft and missile work and must, of course, meet the most extreme environmental conditions.

Strength alone would be reason enough to discuss the merits of silver alloy brazing... and to point out as a reason for its wide acceptance throughout industry. The facts are that there are many more benefits; gas- and leak-tightness, thermal and electrical conductivity, ductility, and production economy – are all *joint qualities* of silver alloy brazing. At any time, we will be happy to discuss any or all of these qualities (and others), as applied to your product or production method. The benefits are large and you can enjoy them.

Your No. 1 SOURCE OF SUPPLY AND AUTHORITY ON BRAZING ALLOYS

HANDY & HARMAN

General Offices:
82 Fulton Street, New York 38, N. Y.
Distributors in Principal Cities

• Bridgeport, Connecticut • Chicago, Illinois • Cleveland, Ohio • Detroit, Michigan • El Monte (Los Angeles), California
Oakland, California • Providence, Rhode Island • Toronto, Canada • Montreal, Canada

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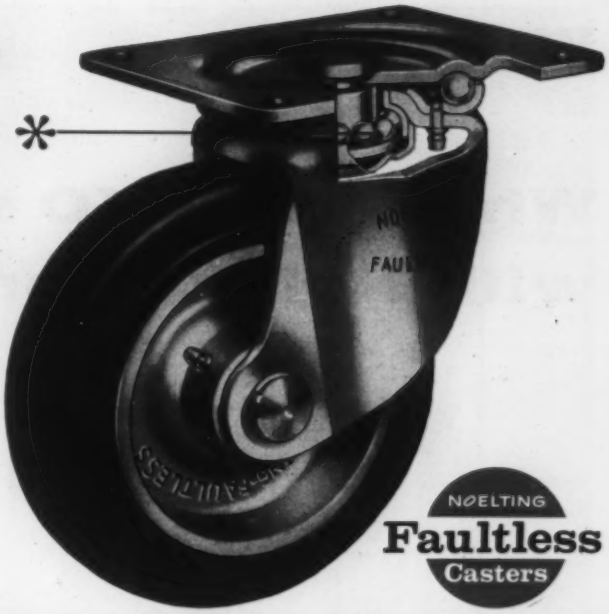
One **RUGGED** Swivel Construction for a whole range of **CASTER DESIGNS**

...assures dependable, low-cost materials handling



NOELTING **Faultless** Casters

The 900 Series Caster and its variations—featuring *2 full rows of ball bearings* rolling in *2 separate, hardened enclosed raceways,* for easy swiveling, heavy gauge steel horn and top plate for extra strength—are examples of the variety and scope of the Faultless line. Freight handling, work scaffolds, automatic tow lines—whatever *your* material handling problem—Faultless, the "Complete Line" backed by nearly three-quarters of a century of caster-making experience, assures you the Caster to best do your job.

Faultless 900 Medium-Heavy Duty Caster

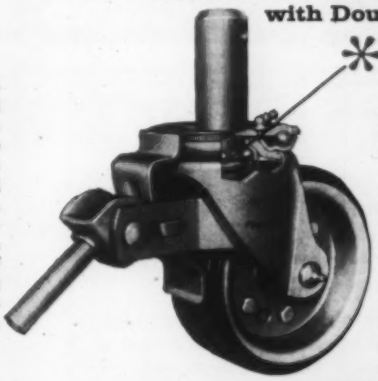
The 900 Series is a rugged, all-purpose Caster with Double Ball Bearing Swivel that out-performs the ordinary kind. Full drawn steel horn formed for surplus strength. Complete selection of wheels to suit floor surfaces, loads and operating conditions make it the ideal choice for use wherever high quality Industrial Casters are needed for medium-heavy duty applications.

Faultless 900GS Caster with Triple Grease Sealed Bearings

Dirt Can't Hurt it!

900 GS combines dependable Faultless Double Ball Bearing Swivel construction with triple grease seals to give positive protection to swivel and wheel bearings wherever dirt, steam, chemicals are encountered—minimizes "down-time." Choice of hard and cushion tread wheels in sizes and capacities from 240 to 650 lbs. per caster.

Faultless C900 Scaffold Caster with Double Safety Locks



Protects Workers on Mobile Equipment

C900 Scaffold Caster combines an easy-to-use foot-operated brake lever which simultaneously locks both swivel and wheel and famous Faultless Double Ball Bearing Swivel construction—assuring safe and positive handling of mobile equipment holding workmen—making it the ideal caster for industrial, military and construction equipment.

ASK YOUR DISTRIBUTOR

Your nearby Faultless Industrial Distributor maintains a substantial inventory of Faultless Casters for immediate delivery. He and one of the strategically located Faultless Sales Engineers are available to work with you on every handling problem in your plant. Both are listed in the phone book Yellow Pages, under "Casters," and the Faultless heading.

WRITE FOR FREE LITERATURE

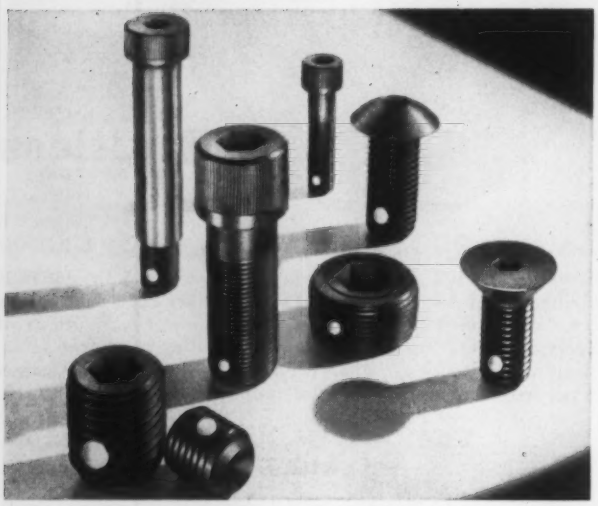
Faultless Caster Corporation
Evansville 7
Indiana

Please send information on the following casters:
☐ 900 Series ☐ 900GS Grease Sealed ☐ C900 Scaffold

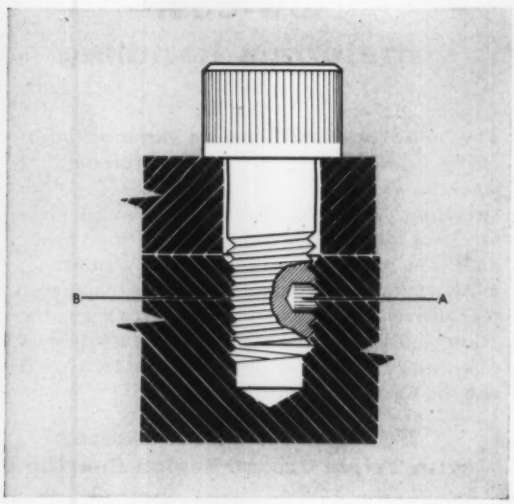
Name _____ Title _____
Firm _____
Address _____
City _____ Zone _____ State _____

SPS RELIABILITY | *A dynamic standard of predictable performance*

Why UNBRAKO socket screws with Nylok* won't work loose



Self-locking UNBRAKO socket screws, in a full range of standard types and sizes, are stocked by your authorized SPS distributor. Permanently installed locking pellets are serviceable from −70 to +250°F and will not dry out, rot or shrink, are not affected by age or fungus.



How Nylok locks: Resilient nylon pellet (A) sets up lateral thrust, smoothly wedging mating threads together (B). Locking action is entirely on threads and is positive, seated or unseated. UNBRAKOs with Nylok are easy to remove and are reusable.

Regular screws loosen under vibration because external stresses cause marked variations in screw tension, resulting in motion between mating threads and loss of frictional holding power.

UNBRAKO socket screws with Nylok stay put, because they do not depend on screw tension to keep them tight. Here is how they work: A tough, resilient nylon pellet, inserted permanently in the threaded section of the screw, is the locking medium. Before assembly, the locking pellet projects slightly beyond the crest of the thread. When mating threads are engaged, it is compressed. Its springlike wedging action grips threads tightly and sets up a counterthrust, creating a strong metal-to-metal engagement of the mating threads. Locking is positive whether the screw is seated or not.

And the permanently installed nylon locking pellet retains strength characteristics from −70 to +250°F.

In addition to their remarkable resistance to loosening under the most severe operating conditions, UNBRAKO self-locking socket screws save production time. They eliminate the need for lockwashers under the heads of screws, drilling of heads for lockwires, cotter pins, and complex multiple set screw installations. And they can be used repeatedly without losing their locking ability.

See your authorized SPS industrial distributor for complete details. Or write SPS—manufacturer of precision threaded industrial fasteners and allied products in many metals, including titanium. Unbrako Socket Screw Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

*T.M. Reg. U.S. Pat. Off., The Nylok Corporation

SPS

Jenkintown • Pennsylvania

Standard Pressed Steel Co. • The Cleveland Cap Screw Co. • Columbia Steel Equipment Co. • National Machine Products Co. • Nutt-Shel Co. • SPS Western • Standco Canada Ltd. • Unbrako Socket Screw Co., Ltd.

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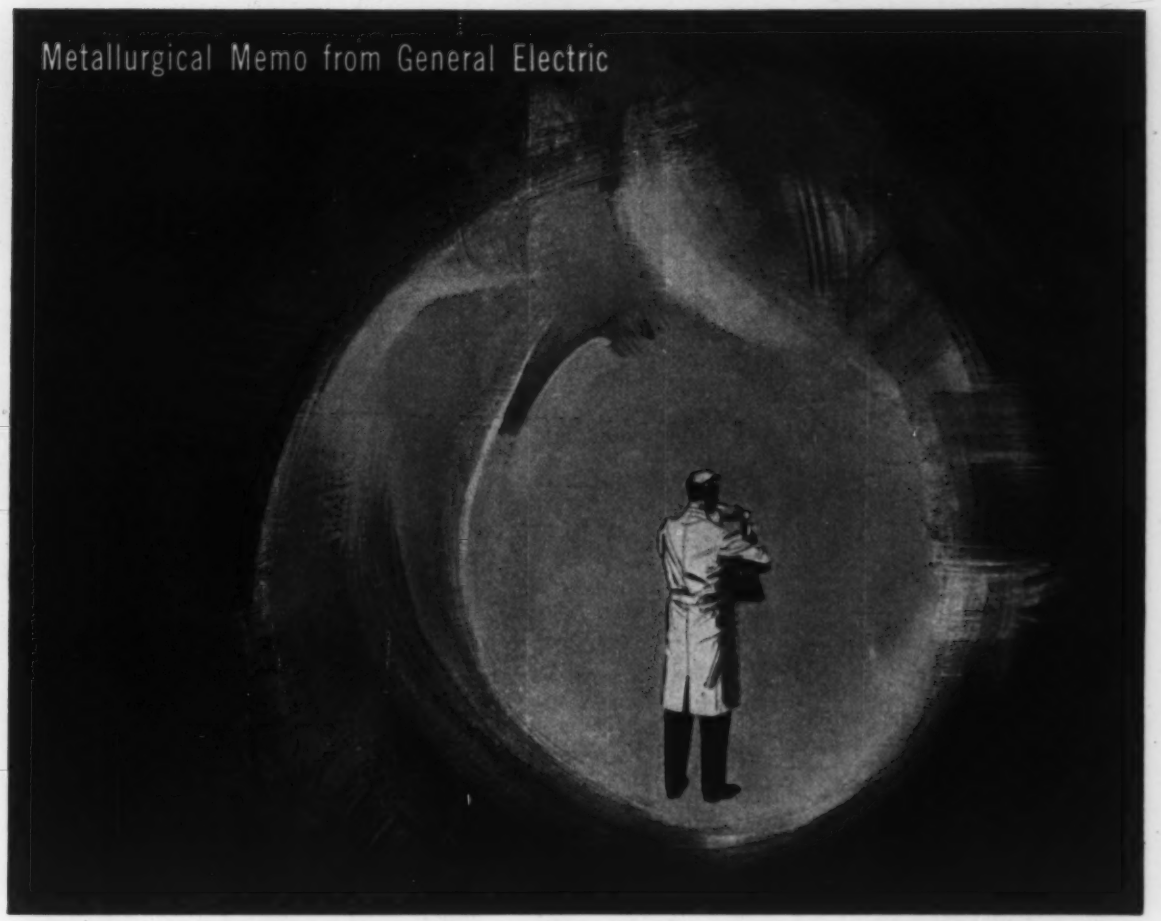

Why it sometimes pays to work in a vacuum

Metallurgical Products Department reports on super-strong vacuum-melted alloys . . . and on how they open vast new areas for mechanical design

By melting existing metals in a near-perfect vacuum, General Electric can give them remarkably improved mechanical properties. These better alloys, *plus* entirely new families of alloys which could not even be made by air melting processes, are lifting mechanical design limitations.

G-E vacuum-melted alloys are exceptionally strong and have increased ductility, making it possible to form, forge, or weld otherwise unworkable metals. Their consistent high purity gives operational dependability to critical gear trains and other machine components. And superior fatigue properties greatly extend the service life of springs and diaphragms.

General Electric vacuum-melted alloys meet exacting specifications and can be ordered in sheets, bars, billets, wire, and castings. If you would like more technical information—or the assistance of a G-E engineer—call or write: *Metallurgical Products Department of General Electric Company, 11159 E. 8 Mile Street, Detroit 32, Michigan.*

METALLURGICAL PRODUCTS DEPARTMENT

GENERAL ELECTRIC

CARBOLOY® CEMENTED CARBIDES • MAN-MADE DIAMONDS • MAGNETIC MATERIALS • THERMISTORS • THYRITE® • VACUUM-MELTED ALLOYS

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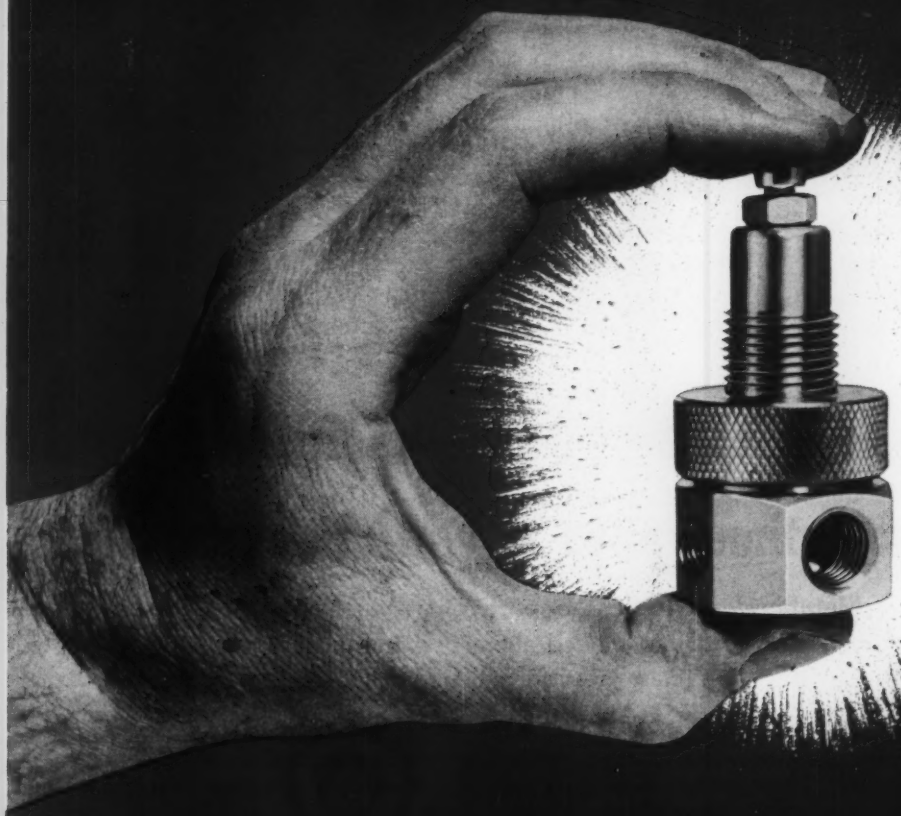
NEW



Best performance of any pressure regulator this small ...at a low, low price!

Norgren

PRESSURE REGULATOR

⅛" and ¼" pipe sizes

for Air, Non-corrosive Gases and Liquids

Best performance of any unit this size

Air Flows Up to 20 cfm at 100 psi air pressure.

Accurate Pressure Regulation even with widely fluctuating line pressure and rapidly varying air flow.

Maximum Primary Pressure: 400 psi.

Maximum Delivery Pressure: 100 psi.

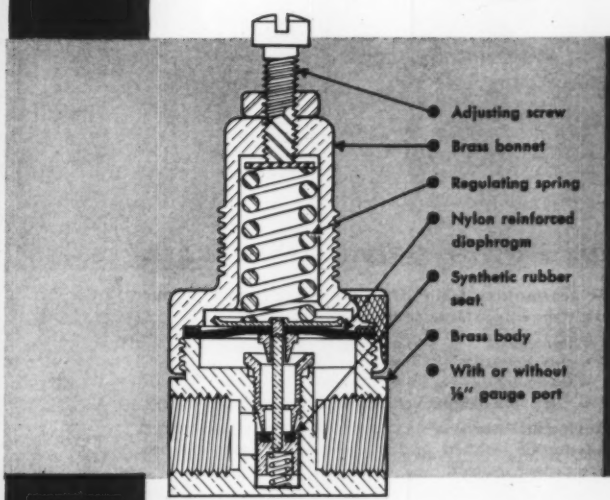
Maximum Operating Temperature: 200°F.

Small Size

The small size of this regulator—only 3¼" high and 1½" in diameter (without gauge)—makes it ideal for installations where space is tight.

Low Price

The lowest price ever for a top quality, dependable pressure regulator.



Plus these important features . . .

- **EASY TO INSTALL**—In-line pipe connections. May be installed in any position.
- **EASY MAINTENANCE**—Should service be necessary, the regulator can be quickly and easily disassembled without removing from line.
- **WITH OR WITHOUT PRESSURE GAUGE**—1½" gauge, 160 psi full scale reading, back mounted.
- **FLOW DIRECTION**—Right to left or left to right.
- **PANEL OR BRACKET MOUNTING AVAILABLE.**

If it's Norgren . . . It's Dependable.

For complete information call your nearby Norgren Representative listed in your telephone directory —or WRITE FACTORY FOR BROCHURE No. 918.

C. A. NORGREN CO.

3442 SO. ELATI STREET • ENGLEWOOD, COLORADO

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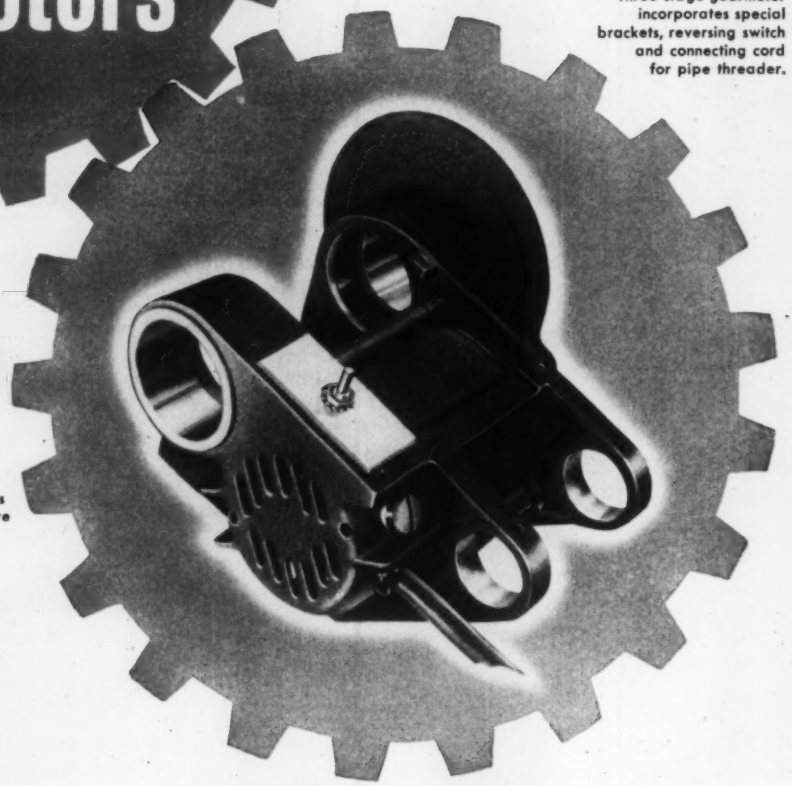
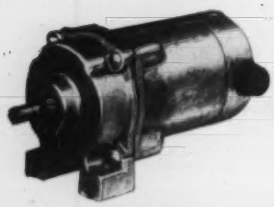
Matching Gearmotors

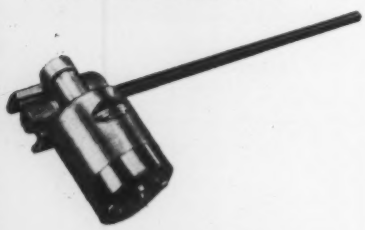


Three-stage gearmotor incorporates special brackets, reversing switch and connecting cord for pipe threader.



Differential planetary gear train allows for unusually compact design in miniature gearmotor for business machines.

Six-pole 400 cycle AC gearmotor for operating tap-changing switch.



Single-stage worm gearmotor. Rolled thread on output shaft actuates traveling nut.

NEW!

8-page Folder describes these and other Lamb motors. Send for your copy.

For Your Power-Driven Products

Lamb Electric gearmotors designed to functionally match your product, provide the important requirements of:

- *low speed*
- *high torque*
- *compactness*
- *dependability*
- *low weight*
- *favorable cost*
- *improved product appearance*

Our manufacturing facilities enable us to build the complete range of sizes and types of hobbed and shaped gears for use with fractional horsepower motors.

Many years of specialized experience in this field, combined with the finest gear cutting and testing equipment, assure unexcelled performance in Lamb Electric gearmotors.

THE LAMB ELECTRIC COMPANY • KENT, OHIO

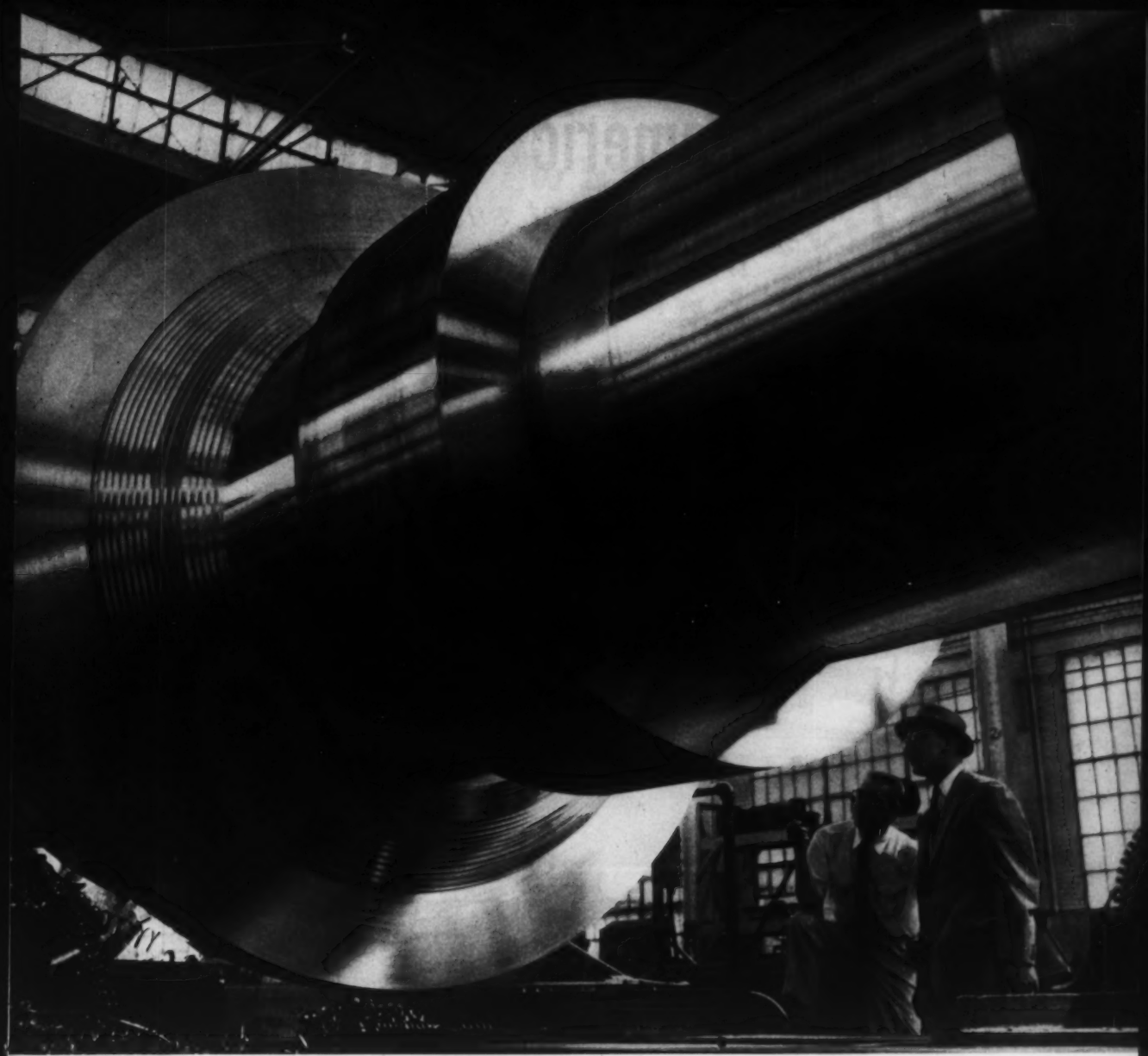
A Division of American Machine and Metals, Inc.

In Canada: Lamb Electric—Division of Sangamo Company Ltd.—Leaside, Ontario

Lamb Electric

SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

Circle 453 on Page 19



Huge shaft to help make power hum

This forged generator shaft is a giant that will do a giant's work. At one of the great Northwestern dams it will take its place in the hydroelectric plant.

The big forging weighs 95 tons, is more than 33 ft long, and has a 15½-in. bore throughout its entire length. Made of carbon-vanadium steel, it was carefully heat-treated to produce the desired mechanical properties.

Huge shafts like this, and other high-tonnage items, are no strangers to the Bethlehem forge and machine shops. Yet Bethlehem forged products are not always king-size. We are equipped to handle all weights and shapes, from the real giants of the family to midget drop forgings.

Call us whenever we can be of service. No matter how complex your designs, Bethlehem technicians will meet all specifications. When Bethlehem does the job, you can be doubly sure of its quality.

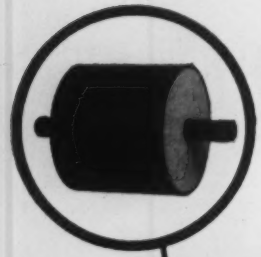
BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

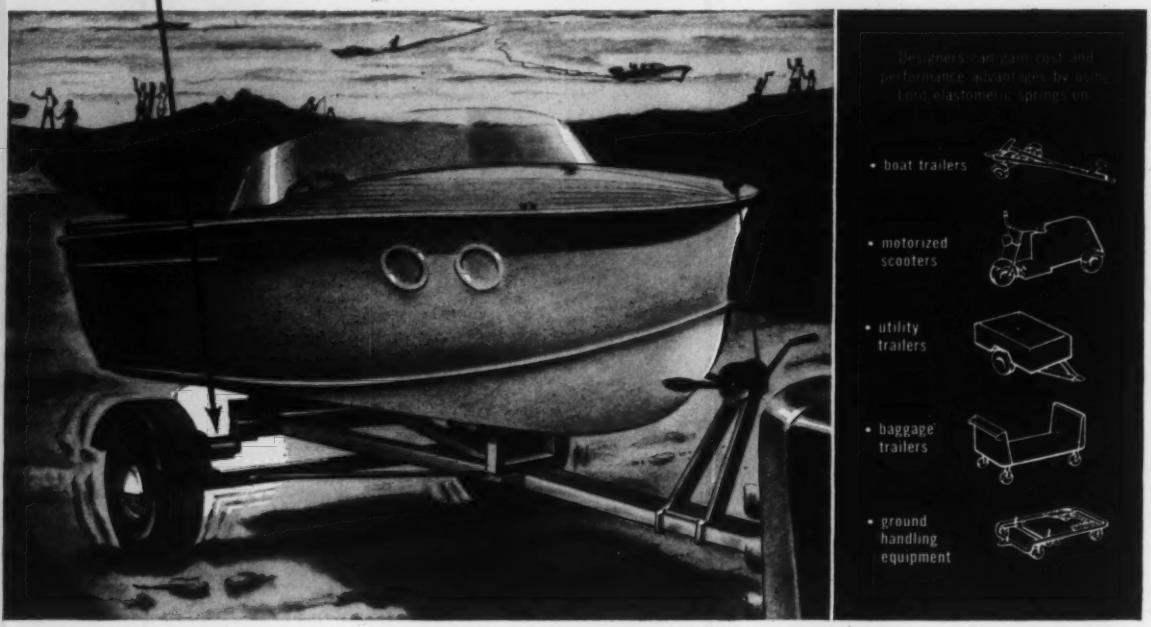
BETHLEHEM STEEL

Circle 454 on Page 19



elastomeric springs:

new, low-cost suspension for trailers and light vehicles

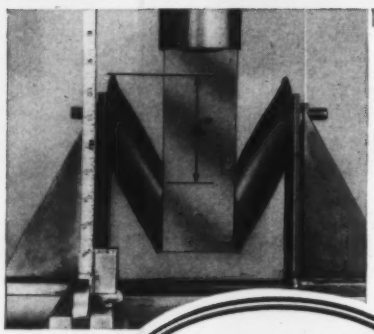

Designers can gain cost and performance advantages by using Lord elastomeric springs on
• boat trailers
• motorized scooters
• utility trailers
• baggage trailers
• ground handling equipment

Take the strength of steel and the long-wearing resilience of rubber. Bond them together permanently in a simplified assembly. The result: an elastomeric spring, today's most promising approach to suspension problems.

LORD elastomeric springs have superior characteristics which introduce vital savings in overall suspension. Shock absorbers are unnecessary due to inherent damping. Good stability characteristics eliminate lateral guide bars. Ease of attachment permits simpler supporting brackets, cuts assembly time and cost. Excellent service life is provided with no maintenance or lubrication required.

A safe, smooth ride is assured by high shock absorbing capacity and multi-directional cushioning. Light and compact, elastomeric springs also provide space savings, lower unsprung weight and a cleaner, more modern appearance.

LORD-designed elastomeric springs are used for thru-axle, individual wheel and dual-axle suspensions over a wide load range. Designers can obtain complete information from the nearest Lord Field Engineer or the Home Office, Erie, Pa.



High strength of elastomeric springs is demonstrated in load-deflection test. They provide greatest energy absorption for given weight and size.

LORD
BONDED RUBBER

FIELD ENGINEERING OFFICES

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BOSTON, MASS. - HAncock 6-9135
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PHILADELPHIA, PA. - PEnnypacker 5-3559
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"In Canada—Railway & Power Engineering Corporation Limited"

LORD MANUFACTURING COMPANY • ERIE, PA.

Circle 455 on Page 19

yours

when you specify Hanna cylinders and valves

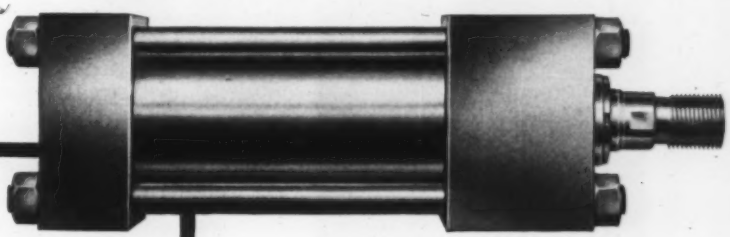
QUALITY • ECONOMY • SERVICE

Your specifications are a part of Hanna Cylinder and Valve design because you get the features you want plus quality, economy and service. In addition you have a complete selection of the most modern cylinders and valves available.

Hanna Cylinders and Valves furnish economical power for thousands of jobs. Not only are they economically priced, but the long life built into these products means that you will continue to operate at minimum cost.

The service offered by Hanna and its more than 60 sales representatives in the United States, Canada, and Foreign Countries can't be beat. Hanna Cylinders and Valves stocked at the Hanna factory and at many representatives' offices help solve your "needed now" problems. Because of efficient Hanna production, "built to order" cylinders take only a few days.

Be sure you specify *Hanna* for all your air and hydraulic Cylinders and Valves.

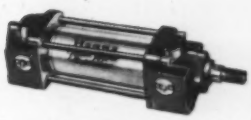


HANNA POWRDRAULIC HYDRAULIC CYLINDERS

2000 and 3000 psi non shock. 1½" through 8" bores.

FEATURING—Pressure Tightening Tube Seals • One Piece Steel Heads with Welded Mountings • Double Seal Piston Rings • Fast Change Cartridge Gland • Lubricated Bearing

Write for Catalog 900



HANNA T750 SERIES FLUID POWER CYLINDERS

Air to 250 psi, Hydraulic to 750 psi. 1½" through 4" bores. Ask for Catalog 750.

HANNA M AND MCC SERIES CYLINDERS

Air to 110 psi, Hydraulic to 150 psi. 5" through 14" bores. Ask for Catalog 236.

Hand Operated Unitite Valves. Catalog 254.

Flo-Set, Speed Control Valves. Bulletin 253.

Flo-Pilot, Pilot Valves. Catalog 262.

Flo-Line, Solenoid and Master Valves. Catalog 261.

Foot Operated Valves. Catalog 254.

Hanna Engineering Works

Phone your nearest Hanna Representative listed in the yellow pages under "Cylinders".

YELLOW PAGES

HYDRAULIC & PNEUMATIC EQUIPMENT • CYLINDERS • VALVES

1751 Elston Avenue — Chicago 22, Illinois

Circle 456 on Page 19

MEL-TROL® gives you **design insurance** on high temperature parts like this

You design for consistent performance. Production demands consistent fabrication properties. You have to have both. If high temperature alloys don't give you both, you'll often find that the cause is lack of uniformity. And you can usually trace it right back to the original ingot your alloy came from.

MEL-TROL stops this kind of trouble before it can start. The newest and most accurate quality controls guard MEL-TROL alloys throughout the steelmaking process. Steel is poured into the new, *Carpenter*-patented ingot mold that produces greater uniformity in the ingot than is possible by conventional steelmaking processes.

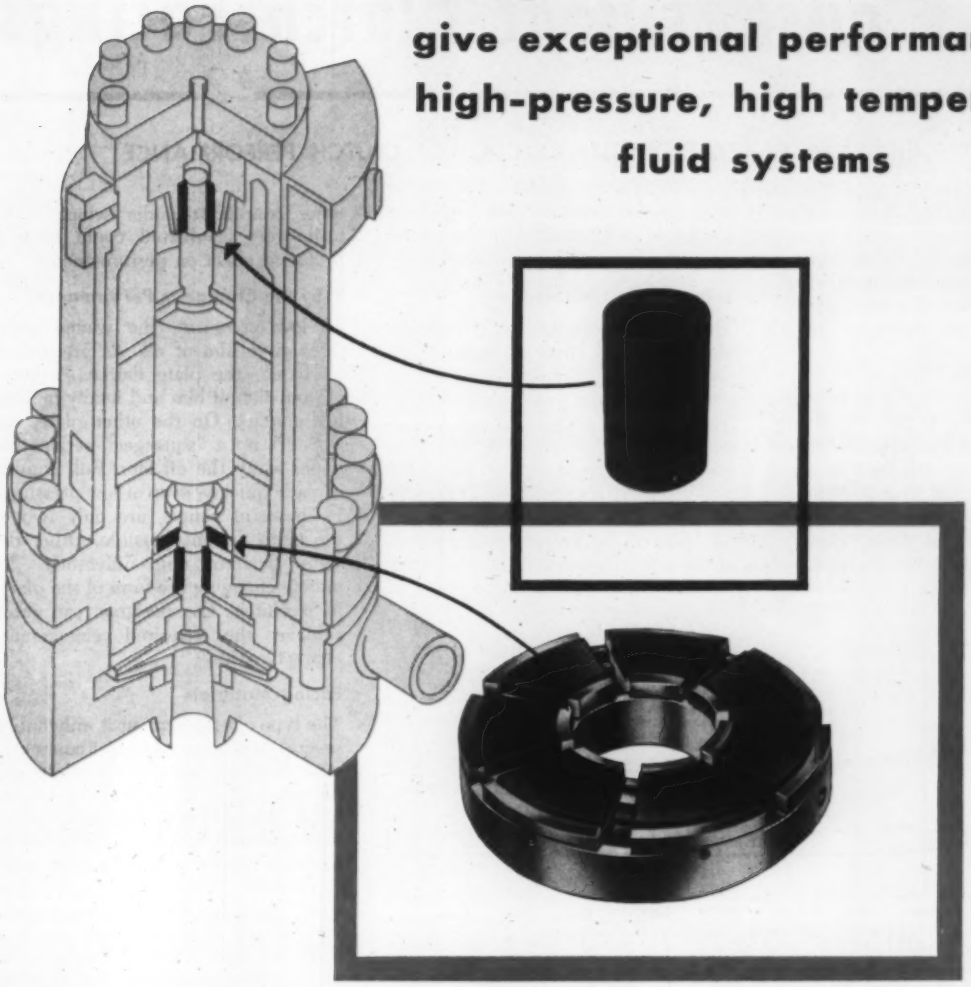
The result is more consistent fabrication behavior and better finished parts. MEL-TROL also pays dividends in high temperature performance over and above conventional steels. Insure the producibility and performance of your high temperature designs with MEL-TROL alloys. Call *Carpenter* for the alloy you need, today.

Carpenter STEEL

The Carpenter Steel Company
Main Office and Mills, Reading, Pa.
Alloy Tube Division, Union, N. J.
Webb Wire Division, New Brunswick, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.

Circle 457 on Page 19

water-lubricated GRAPHITAR® (CARBON-GRAPHITE) bearings in "canned" motor pumps give exceptional performance in high-pressure, high temperature fluid systems



Special hermetically sealed motor-pumps, known also as "canned" motor pumps, were developed by Westinghouse Electric Corporation to handle radioactive water with zero leakage. These same pumps have proven a convenient means of pumping high temperature fluids for a number of nuclear reactors and other high pressure, high temperature fluid applications.

The thrust bearing utilized in the "canned" motor pump is a self-equalizing, water-lubricated, pivoted-pad bearing with inserted GRAPHITAR bearing surfaces. The radial sleeve bearings are also made of GRAPHITAR and are designed to be lubricated by the pumped fluid only . . . in the case of pumps used in nuclear reactors, only radioactive hot water is employed as lubrication.

GRAPHITAR is utilized extensively in tough applications because of its many unusual properties. It is non-metallic, resists chemical attack, has self-lubricating properties, a low coefficient of friction, is mechanically strong, hard as steel and lighter than magnesium. GRAPHITAR will not warp and shows no expansion or contraction in extreme temperature changes.

This versatile engineering material, GRAPHITAR, may well solve one of your difficult design problems. For further information on GRAPHITAR and its many applications, send for our engineering manual No. 20.

R-266-1

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDERED METAL PARTS • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

Design Data on Resilient Clutch Facings

#2

HOW CHANGES IN PLATE DESIGN CAN AFFECT CLUTCH PERFORMANCE

A series of laboratory dynamometer tests, summarized in the graph below, illustrate how varying plate design can change the apparent (or effective) coefficient of friction of a resilient facing material in a wet clutch.

Coefficient of Friction

As the graph shows, under an engagement pressure of 150 psi, the facing material has about the same coefficient of friction on a waved plate as on a flat slotted plate. But at a pressure of 30 psi, the coefficient of friction is much higher with the slotted plate.

Note also that with the slotted plate an inverse relationship exists between engagement pressure and apparent coefficient of friction. With the waved plate, the relationship is direct.

Engagement Characteristics

These design changes will obviously have a marked effect on engagement characteristics. Because the slotted plate provides a high coefficient of friction at low pressure, it has a short period of slip, engages rapidly. The waved plate picks up torque more slowly—gives a smoother engagement.

(Note: This example illustrates only the general operating characteristics of flat slotted plates and waved plates. Changing the facings or any of the other conditions under which these tests were conducted could have a profound effect on performance.)

Why the Change in Performance?

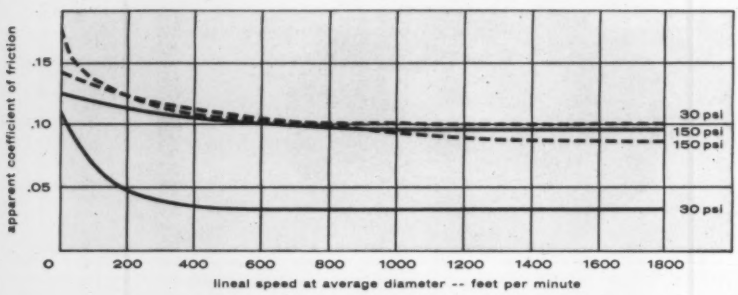
At low pressures, the waved plate rides on a film of oil. As pressure is increased, the plate flattens, squeezing out the oil film and finally making full contact. On the other plate, the slots set up a "squeegee" action that wipes away the oil film. Full contact is made quickly, even at low pressures.

These, of course, are only two of the plate designs possible. Other designs perform still differently. By merely changing the form of the plates in a clutch, the designer can often achieve the required engagement characteristics.

Facing Materials

The type of engagement is only one of several performance requirements in most clutches. Some of the others are: permanence of characteristics for the life of the unit; and durability, including resistance to wear, high temperatures, pressures, and lubricating oils.

To satisfy these requirements, there is a wide range of Armstrong resilient friction materials available. Each of them is compounded for a different set of operating conditions. The right resilient facing, combined with proper plate design, will deliver optimum performance in most applications.

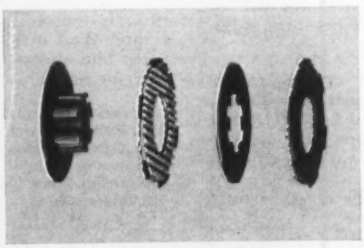


This graph compares the test performance of a flat slotted plate (dotted lines) with a waved plain plate. Both were faced with the same Armstrong resilient material and were run in type "A" transmission fluid at 200° F. Dimensions of the facings were 7½" O.D. x 6¼" I.D. The slotted plate had 1/16" radial slots dividing plate and facing into six equal segments.

HOW TO GET HIGH TORQUE CAPACITY WITH FEWER CLUTCH PLATES

In many wet clutches, torque requirements and space limitations make it necessary to use more than one clutch plate.

Armstrong resilient friction materials often are quite effective in applications of this kind. These materials have an unusually high coefficient of friction. And they retain more of their frictional properties when coated with



oil than any other type clutch facing.

As a result, Armstrong friction materials can transmit a given torque with fewer clutch plates. An outstanding example is pictured here. In this automatic washer clutch, three Armstrong facings delivered the same torque capacity as the eight metallic surfaces they replaced. Naturally, this change to resilient materials meant considerable savings in metal costs, fabrication, and assembly.

If you have a problem involving friction materials, send the details of your application to Armstrong Cork Company, Industrial Division, 7204 Dean Street, Lancaster, Pennsylvania.

Armstrong RESILIENT FRICTION MATERIALS

... used wherever performance counts

Circle 459 on Page 19

This Sandusky Centrifugal Casting—one of four produced for Westinghouse Atomic Equipment Department—meets radiographic, intergranular corrosion, and all other rigorous chemical and physical tests.

ONE SANDUSKY CENTRIFUGAL CASTING ...makes 4 giant stator shells

Specified by Westinghouse for 4 canned motor pumps soon to be integral parts of reactor system in Yankee Atomic Electric Plant in Rowe, Massachusetts

One king-size 17-ton Sandusky casting supplied the main motor bodies (stator shells) for the four pumps being built by Westinghouse, each to handle 23,600 g.p.m. of pressurized water through the reactor core.

The 25-foot-long Sandusky casting was centrifugally spun of a modified CF-8 (Type 304 L) stainless steel, then machined by Sandusky to a 3" wall thickness, 31½" on the O.D. This huge casting was hydrostatically tested to 3800 psi before being sectioned into four 68" lengths.

These stator shells represent another *new and exacting application* for Sandusky Centrifugal Castings—which may offer a practical and economical answer to *your* cylindrical requirements also. They are available in diameters from 7" to 54"—in lengths up to 33 feet—in heat- and corrosion-resistant stainless, carbon and low-alloy steels and a wide range of copper-base and nickel-base alloys.

Let us show you how Sandusky Centrifugal Castings can help solve your cylindrical problems. Write to us at Sandusky, Ohio.

SANDUSKY CENTRIFUGAL CASTINGS

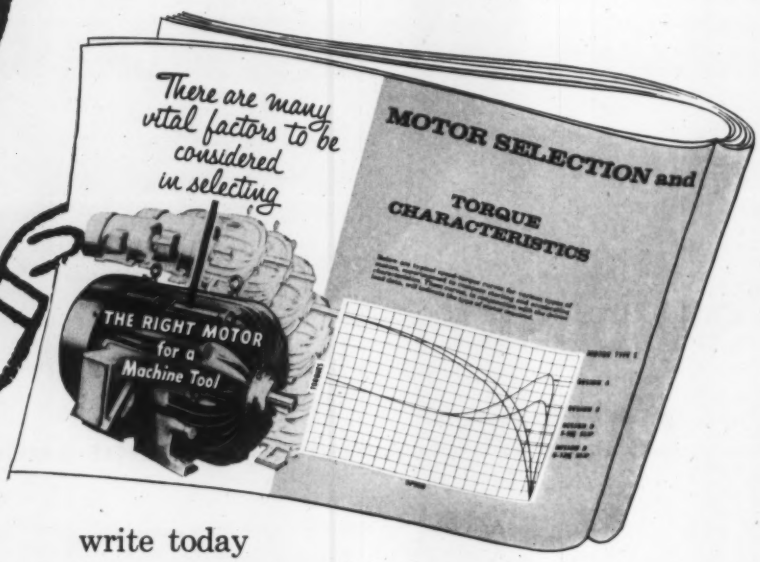
SANDUSKY FOUNDRY & MACHINE CO.

SANDUSKY, OHIO Stainless, Carbon, Low-Alloy Steels—Full Range Copper-Base, Nickel-Base Alloys

Circle 460 on Page 19

NEW BOOKLET

helps you choose the RIGHT motor for better machine tool performance


There are many vital factors to be considered in selecting
THE RIGHT MOTOR for a Machine Tool
MOTOR SELECTION and
TORQUE CHARACTERISTICS

write today
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It's just off the press—and filled with information that may help you improve your products! What are the factors involved in proper motor selection? How can you specify motors that will deliver all the speed, precision and performance you build into your machine tools? What are the engineering features that guarantee dependable operation and long motor life? This book tells you. Send today for "THE UNDERCOVER STORY . . . What to Look for under the Frame in Motors for Machine Tools."

ME®

MARATHON ELECTRIC

MARATHON ELECTRIC MANUFACTURING CORPORATION
Wausau, Wisconsin

Circle 461 on Page 19

Some Ideas

for your file of practical information on drafting and reproduction from

KEUFFEL & ESSER CO.

One of the ways to judge a skilled craftsman is by the tools he uses. They're invariably the best he can find – chosen to lighten his work, sharpen his skills. And, if the craftsman is a draftsman, they are, more often than not, products of K&E.

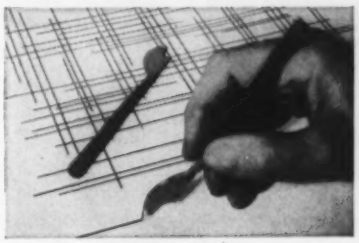
It may be that some of these products have escaped your attention (after all, we offer something over 8000 items). That's why we suggest you pay a visit to your K&E dealer whenever you can. It's a liberal education on what's new – as well as what's tried and true – in drafting equipment.

You'll find many products like these which can be highly useful in your work . . .

K&E "Quick Set" Bow Compass

The most remarkable feature of this compass is the speed and ease with which you can change settings–from diameters of 12 inches to 1/16 inch. With one hand, you can increase or decrease radii instantly and exactly. To go from small to larger radius, just press a spring release, and the legs will expand automatically. Stop approximately where you want, and make precise adjustments with a micrometer screw. To go from large to small, simply squeeze the legs of the compass together, then adjust precisely.

The K&E Quick Set combines the rigidity and precise adjustment of a standard bow compass, the simplicity and speed of a friction type compass, plus the finger tip control of K&E's unique design. You have to try the Quick Set to appreciate it fully. Two types are available. The N1071 fixed leg pencil compass, and the N1070 combination with interchangeable pen and pencil inserts. Both come with a box containing leads and spare needles. And with the N1070, a pen handle is provided for the pen insert which permits its use as a ruling pen. The compass can also be used as a divider by substituting one of the spare needle points for the lead in the pencil insert.



Marathon® Ruling Pens

K&E Marathon Long Line and Wide Line Ruling Pens (1092) hold an extra large ink supply – draw lines up to eight times longer than ordinary ruling pens. And because they are pre-set, line widths are always uniform, easy to match with complete accuracy. Ink flow is regular and even, lines are always sharp and clean edged.

An important feature of K&E Marathon Ruling Pens is that they will *not leak*. They can be laid on the work surface without risk of ink flowing out. That means you can fill several pens of different widths, use them as freely as you'd use pencils. They're easy to clean, too.

K&E Marathon Long Line Ruling Pens are available individually in line widths of .006, .009, .013, .020 inch – or in sets of three pens in line widths of .009, .013, .020 inch in a Leatherite case. Marathon *Wide Line* Ruling Pens come in line widths of .030 and .060 inch.

Leroy® Height and Slant Control Scriber

A versatile new Leroy scriber is now available which greatly expands the variety of lettering possible from a standard Leroy template.

Now, with the new Height and Slant Control Scriber (3237-12), you can form characters from vertical to slanting at any angle up to 45° forward. You can vary height from 60% to 150% of the size of letters on the template used. The width of letters remains the same.

Combinations of height and slant can be set quickly and easily. You just loosen the knob, move the scriber arm to the desired combination of height and slant, and tighten. That's all there is to it.

Stop in to see your nearest K&E dealer and ask to see these three products–small, perhaps, but mighty handy in the drafting room. Or drop us a line by mailing the coupon below . . .

KEUFFEL & ESSER CO., Dept. MD-4, Hoboken, N. J.

I'd like more information on:

- ☐ K&E Quick Set Compass
- ☐ Marathon Ruling Pens
- ☐ Leroy Height and Slant Control Scriber
- ☐ Please send me the name and address of my nearest K&E Dealer.

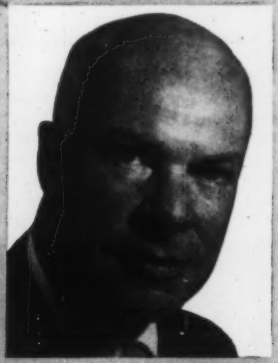
Name & Title_____

Company & Address_____

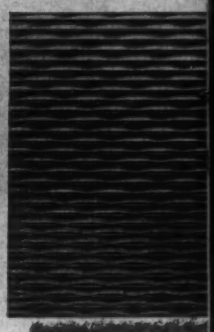
_____ 1613

Circle 463 on Page 19→

Peter Schladermundt, A.I.A., A.S.I.D., P.D.C., for 25 years a leading designer of many of America's foremost industrial products. Formerly associated with Norman Bel Geddes and other designers and architects on such projects as General Motors "FUTURAMA" and the design of Rockefeller Centre. Presently heading his own firm specializing in all types of design service to industry. Recently designed the Trade Fairs for the United States Government Department of Commerce in Milan and Paris.



Peter Schladermundt and Sharonart combine for a new design concept....



Tomorrow's business machines will have the low, sleek profile and functional beauty you see in this typewriter design created by the nationally known industrial designer Peter Schladermundt especially for the Sharon Steel Corporation.

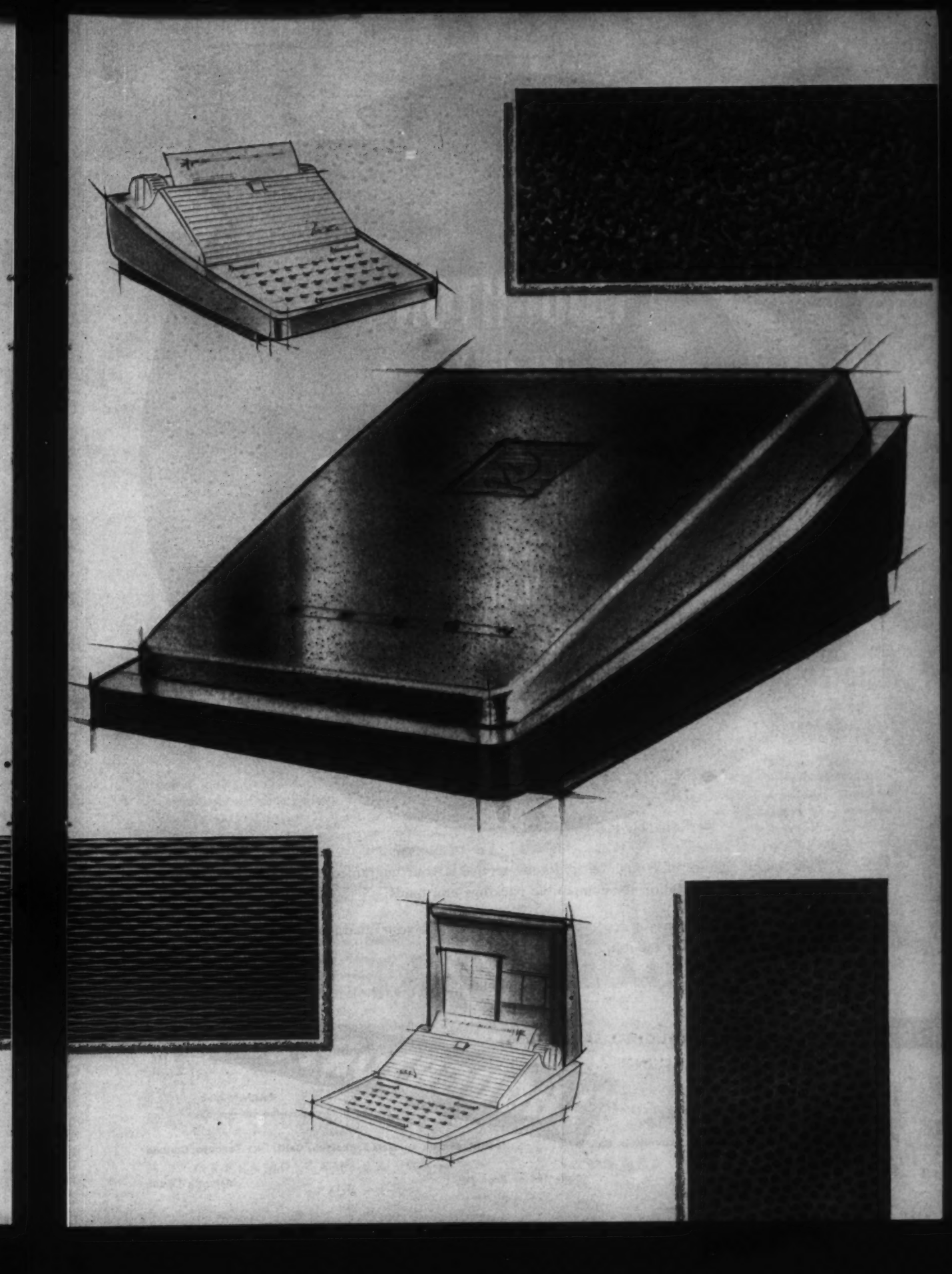
Gone is the bothersome cloth cover and in its stead a regular built-in secretarial workshop that includes typewriter accessory and lighted shorthand book and note compartments. And when the day is through the desk area is made neat by simply dropping the attractive machine lid.

Ingenious? Yes, but perhaps the most important aspect of the design is the functional use of Sharonart, Sharon's popular patterned steel. By fashioning the work areas of Sharonart the usual marks of wear never show, and by forming the cover of this amazing metal many styles are immediately available to the manufacturer by simply changing the pattern . . . and here, too, wear is practically eliminated.

It's the kind of forward thinking that has made Sharonart the most popular material of its kind. Literature and information available from the Sharon salesman in your area or by writing direct to *Sharon Steel Corporation, Sharon Pa.*

SHARONSTEEL

SHARON *Quality* **STEEL**



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This unique feature of Houghton hydraulic service is your guarantee of a completely unbiased recommendation for compatible packings and fluids.

Houghton's reputation for leadership in both fields, is your guarantee of the best packings and fluids for the job.

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HYDRO-DRIVE & HOUGHTO-SAFE FLUIDS
VIM & VIX-SYN PACKINGS . . .

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Ready to give you on-the-job service

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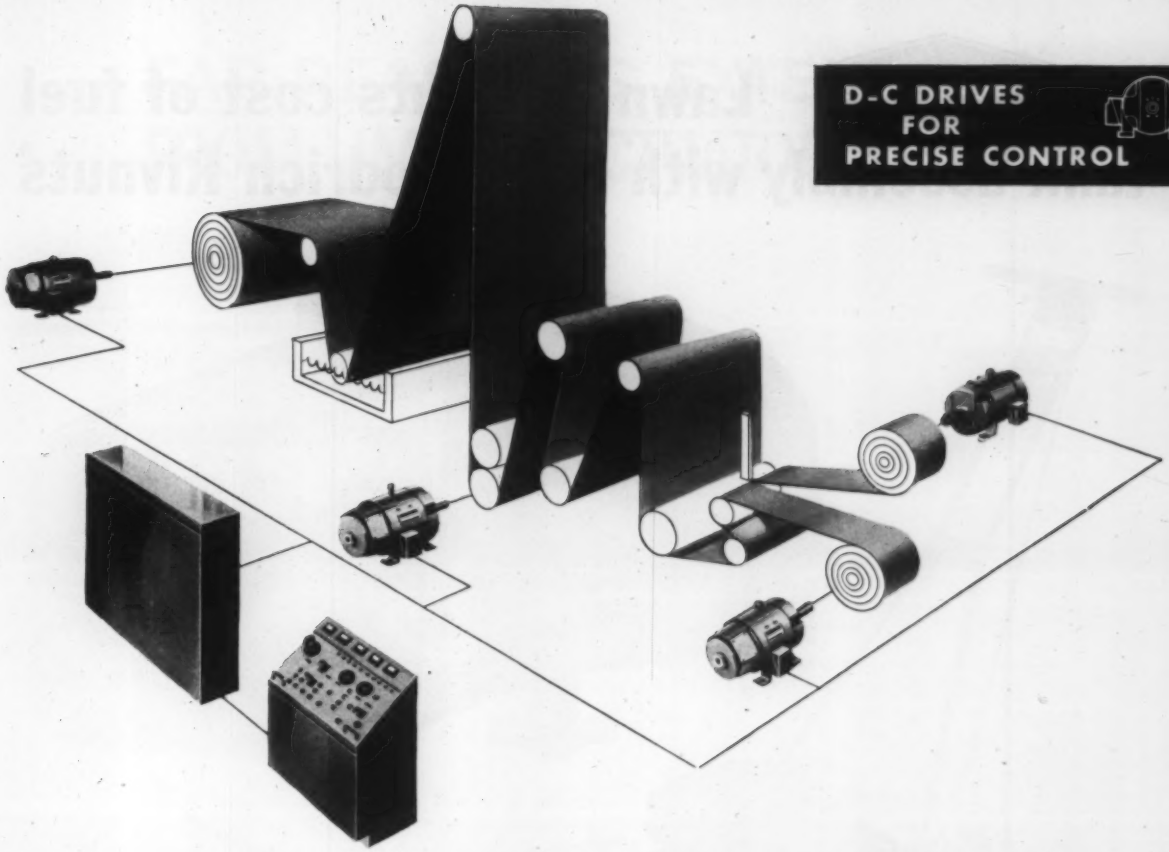
D-C DRIVES FOR PRECISE CONTROL



Problem: How to control sheet or web tensions for faster machine operation, better quality

Tension inaccuracies during high speed production can result in torn sheet, costly production snarls, poor product quality. To control sheet or web tensions accurately, speeds of machines must be closely synchronized. Equipment must be brought up to top speed gradually—smoothly—without loss of tension. Often a dozen motors must respond as one—instantly. **Direct-current drives can best meet this need.**

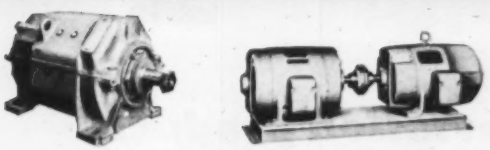
In continuous processing—wherever accurate control is needed—direct-current adjustable-speed drives perform with instantaneous tension adjustment—smoothly, automatically. The result: faster machine operation, better quality, lower production cost.

This is only one example of d-c's modern capabilities. Throughout industry there is a growing trend to more direct-current powered equipment. The reasons for this trend are explained in a new General Electric booklet called "WHY D-C?" For your free copy, write *Department 829-1, General Electric Co., Schenectady 5, New York.*

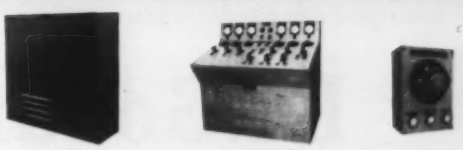
Progress Is Our Most Important Product

GENERAL ELECTRIC

SELECT FROM G.E.'S COMPLETE LINE OF D-C DRIVES



MOTORS AND GENERATORS



POWER UNITS AND CONTROLS

Circle 465 on Page 19

B.F.Goodrich

Lawn Boy cuts cost of fuel tank assembly with B. F. Goodrich Rivnuts®

When Lawn Boy designed their current power mower models, they decided to *suspend* the fuel tank underneath the streamlined shroud. But in order to do this they needed specialized fasteners that would fit inside the tank and provide shock-proof, fuel-tight nutplates.

They found that B. F. Goodrich Rivnuts would do this job better and more economically than any other fastener. Here's how. After the tank is formed, two holes are punched in its top. One man takes only a few seconds to upset Rivnuts in these holes. Screws are then inserted through the shroud and into the Rivnuts, attaching the tank solidly.

B.F.Goodrich Rivnuts provide firm nutplates that won't vibrate loose during operation of the mower. In addition, the special closed ends and tight clinching action of Rivnuts form a 100% fuel-tight seal.

Rivnuts can be used hundreds of ways to simplify production—give your products more eye-appeal, more sales-appeal! If you haven't already investigated their potential in your own business, why not do it now?

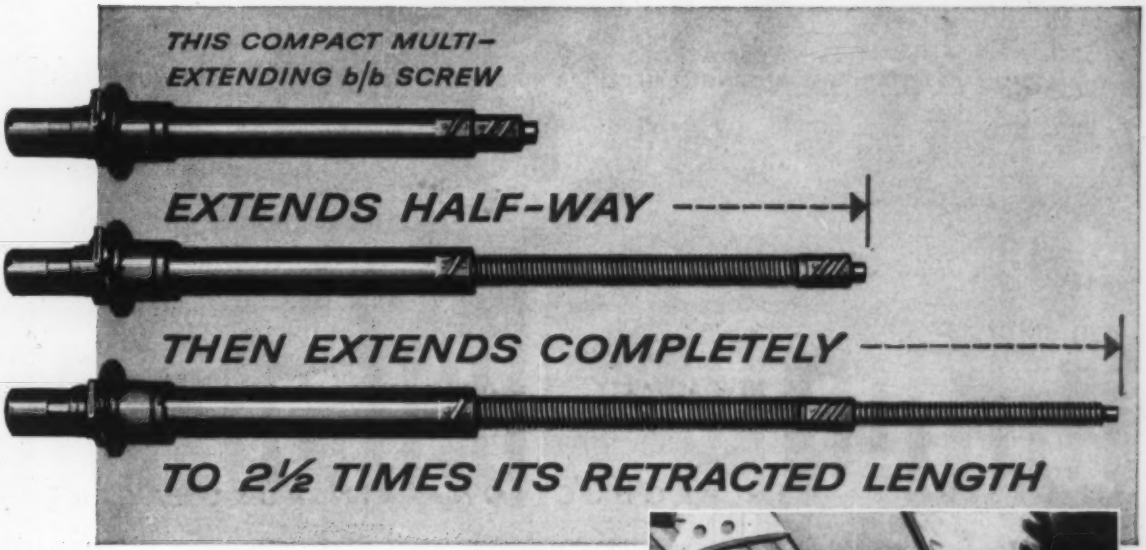
Send today for free Rivnut Demonstrator

Demonstrates with motion how you can use Rivnuts to fasten TO and WITH. Explains construction, simplicity of installation. Get your free copy today by writing to: *B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Company, Dept. MD-49, Akron, Ohio.*

B.F.Goodrich *aviation products*

Circle 466 on Page 19

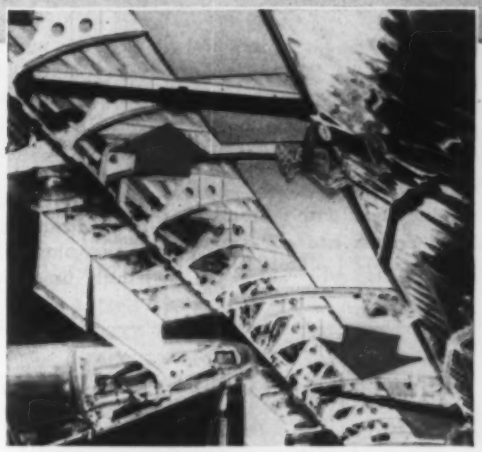
FAR-REACHING EXTENSION FROM LIMITED ACTUATOR SPACE



Now Saginaw supplies the answer to your most difficult actuator space problems with the Multi-Extending Saginaw Screw! Utilizing Saginaw's time-proved *recirculating ball* principle in multiple telescoping sections, the Multi-Extending b/b Screw conquers actuator space obstacles designers have been seeking to overcome for years! Here's why:

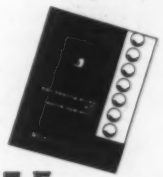
1. **UNIT EXTENDS** in a ratio of 2.5 to 1, providing maximum extension 2½ times the length of the retracted screw.
2. **FAR GREATER LOAD CAPACITY** than any other telescoping device in its class.
3. **FAR MORE PRACTICAL AND TROUBLE-FREE** than other telescoping units on the market.
4. **PRECISE, DEPENDABLE POSITIONING** and control within thousandths of an inch.

• OVER 90% EFFICIENCY • REQUIRES UP TO 4/5 LESS TORQUE than acme screws • LESS DRAIN on power supply • CONSERVES SPACE AND WEIGHT • OPERATES DEPENDABLY at extreme temperatures • PERFECT FUNCTIONING with only initial lubrication



USED ON THE COUNTRY'S MOST MODERN AIRCRAFT—Multi-Extending b/b Screw wing flap actuators being installed on the new Lockheed Electra.

The Saginaw Multi-Extending Screw is also used to actuate speed brakes, afterburners, variable air inlets, canopies and similar critical components on today's newest aircraft.



Send today for the new 1959 engineering data book on Saginaw b/b Screws and Splines... or see our section in Sweets Product Design File.

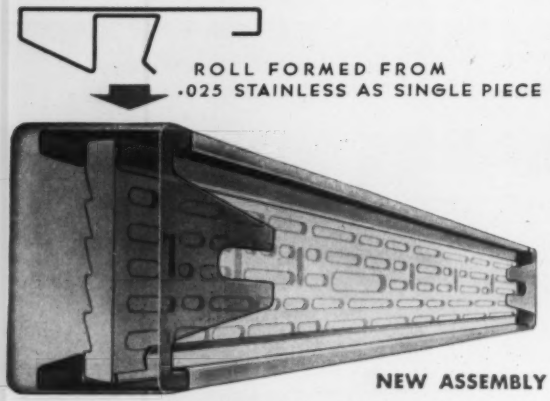
Saginaw

WORLD'S MOST EFFICIENT ACTUATION DEVICE

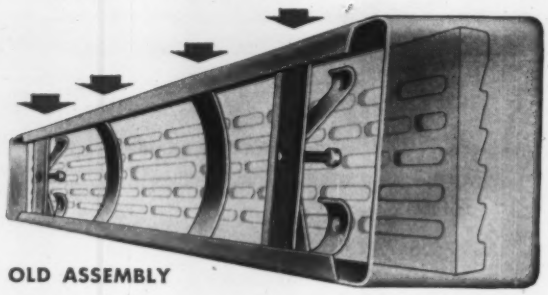
ball bearing Screw

SAGINAW STEERING GEAR DIVISION, GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN

how one Roll Formed shape *eliminated six clips* and simplified an assembly



NEW ASSEMBLY



OLD ASSEMBLY

IN DESIGN

An expensive stamping and six clips went into this assembly. The stamping had a bad finish and cracked. Now it's Roll Formed from stainless. The finish is bright, shining and can't stain in use. Cracks are eliminated.

IN PRODUCTION

With the stamping the customer inserted a plastic strip and then welded the clips to retain the strip. Screws were positioned manually. Stampings were not uniform. Plastic breakage was high. The new Roll Formed section eliminates the welding operation, guarantees close tolerances, eliminates plastic breakage and cuts assembly time. Screws are not needed.

IN PURCHASING

Rejects were high. Components were hard to get and stampings came from separate suppliers. Deliveries were off-schedule. Now—Roll Formed sections come from one source and are delivered weekly to an open order. Stainless sections are interwoven with paper to protect finishes. Rejects have been eliminated.

CAN TECHNIQUES LIKE THESE HELP YOU?

Probably yes. The Roll Formed man can tell you. He'll go over your prints . . . work out an applicable section . . . plan deliveries with you. Meanwhile, you'll want Roll Formed Bulletin 1017A. It shows how Roll Formed techniques give greater design freedom, increase production and help eliminate purchasing headaches. Get Bulletin 1017A today.

METALS AND TECHNIQUES

Your sections can be produced in: carbon, galvanized and stainless steel; aluminum, copper, zinc and clad metals. Tubing, shapes, channels and angles can be punched, notched, pierced, cut to length and delivered free of burrs to match your production schedule.

MAIN OFFICE AND PLANT
3754 OAKWOOD AVE., YOUNGSTOWN, OHIO

ROLL FORMED PRODUCTS
COMPANY

Circle 468 on Page 19

AVOID the **HIGH COST** and difficulty of fabricating long, hard & straight parts by conventional methods . . .

THOMSON

60 Case

hardened and ground

SHAFTS, ROLLS, GUIDE RODS and other long-round parts

60 Case is the result of over ten years of experimental work and production experience with hardened and ground shafts which are a requirement for BALL BUSHINGS, the Linear Ball Bearing manufactured by Thomson Industries, Inc.

The special techniques and equipment that have been developed enable high production rates and low handling costs. This permits big savings over conventional methods which are plagued with erratic warpage, straightening and resultant grinding problems. Finished *60 Case* parts frequently cost less than the scrap losses that result from conventional methods.

60 Case material has a surface hardness close to 60 on the Rockwell C scale which is essential to resist wear.

Long lengths of material ranging in diameter from ¼" to 4" are stocked to enable prompt shipment of *60 Case* parts, with or without special machining.

Write for literature and name of your local representative.

For emergency needs call collect MAnhasset 7-1800

ADVANTAGES of *60 Case*

- COST REDUCTION
- HARD BEARING SURFACE
- ACCURATE DIAMETERS
- GROUND FINISH
- STRAIGHT PARTS
- DELIVERY FROM STOCK
- ADDED STRENGTH
- UNIFORM HIGH QUALITY

TYPICAL *60 Case* PARTS

GUIDE RODS, SHAFTING, ROLLS, TRAVERSE RAILS, PISTON RODS, ARBORS, LEADER PINS, TIE RODS, KING PINS, AXLES, CONTROL RODS, GUIDE POSTS, MANDRELS, BEARING ROLLERS, SPINDLES

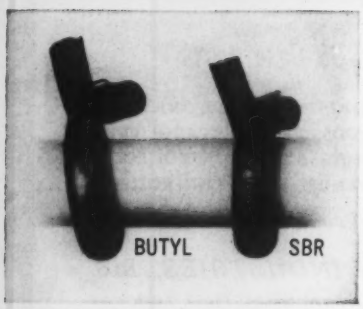
THOMSON INDUSTRIES, Inc.

Dept. C-5, Manhasset, New York

Circle 469 on Page 19

ENJAY BUTYL

FOR RESISTANCE TO SUNLIGHT AND WEATHERING



Butyl's high resistance to ozone is graphically demonstrated when compared with SBR or natural rubber

Enjay Butyl rubber has demonstrated for many years its outstanding ability to resist deterioration caused by sunlight and weathering. This inherent resistance of Butyl to ultra-violet light, ozone, oxidation, moisture and mildew, has made possible many new and colorful products. Butyl has also increased the life of other products such as weatherstrips, protective coating, garden hose, wading pools and many automotive parts.

Butyl *also* offers...outstanding resistance to chemicals, abrasion, tear and flexing . . . superior damping qualities . . . unmatched electrical properties and impermeability to gases and moisture.

For more information call or write the Enjay Company.

ENJAY® BUTYL

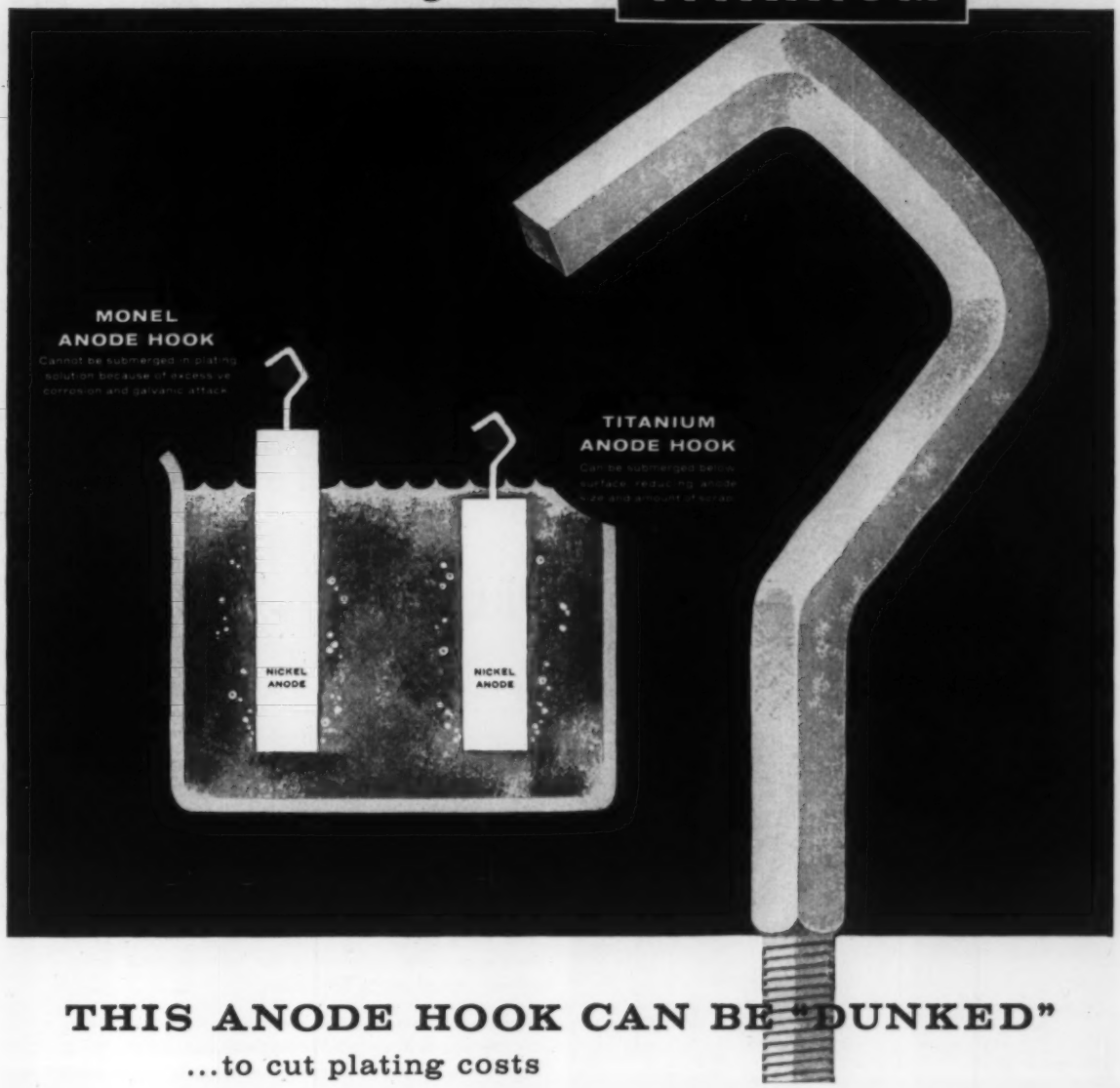
EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY COMPANY, INC., *15 West 51st Street, New York 19, N. Y.*

Akron • Boston • Charlotte • Chicago • Detroit • Los Angeles • New Orleans • Tulsa

Circle 470 on Page 19

Cost cutting ideas in **TITANIUM**


MONEL
ANODE HOOK
Cannot be submerged in plating solution because of excessive corrosion and galvanic attack
TITANIUM
ANODE HOOK
Can be submerged below surface, reducing anode size and amount of scrap
NICKEL ANODE
NICKEL ANODE

THIS ANODE HOOK CAN BE "DUNKED"

...to cut plating costs

IF YOU'RE PLATING PARTS with nickel, chromium or copper, here's a cost-cutting idea worth investigating.

The titanium anode hook illustrated above offers important advantages in highly corrosive plating applications. For example, because of titanium's extreme resistance to corrosion, the bare hook can be "dunked" in nickel plating solutions. This means you use up practically *all* of the anode—reducing costly scrap waste. In addition, the titanium hook lasts indefinitely.

Titanium hooks, anode baskets and heating coils are now cutting costs in a number of large-scale plating applications... examples of how Mallory-Sharon's development work in titanium is paying off for industry.

Write for Technical Data Sheet and application information on titanium anode hooks, or any other high-corrosion problems you may have. Please address: Commercial Market Development, Dept. A, Mallory-Sharon Metals Corp., Niles, Ohio.

MALLORY SHARON

MALLORY-SHARON METALS CORPORATION · NILES, OHIO

Integrated producer of Titanium • Zirconium • Special Metals

Circle 471 on Page 19

AMWELD®

always a dependable fabricator for WELDED PRECISION ASSEMBLIES

As a major supplier of millions of rings, bands and welded assemblies to the aircraft industry, American Welding developed highly successful techniques for producing circular parts and components. Today they are applying these skills to the problems involved in missile production. These facilities, which include metal forming, welding, and machining, are available on a sub-contract basis. Complete metallurgical and engineering staffs, plus a work force skilled in the fabrication and welding of stainless steel, titanium, aluminum, and heat-resistant alloys, are ready to work with you. And, along experimental lines, American Welding operates a separate department for exploring new possibilities of fabricating by welding.

If you would like to obtain complete information on the capabilities of American Welding and how we can be of assistance to you — phone or write today. Our local representative will be happy to call and discuss your requirements.

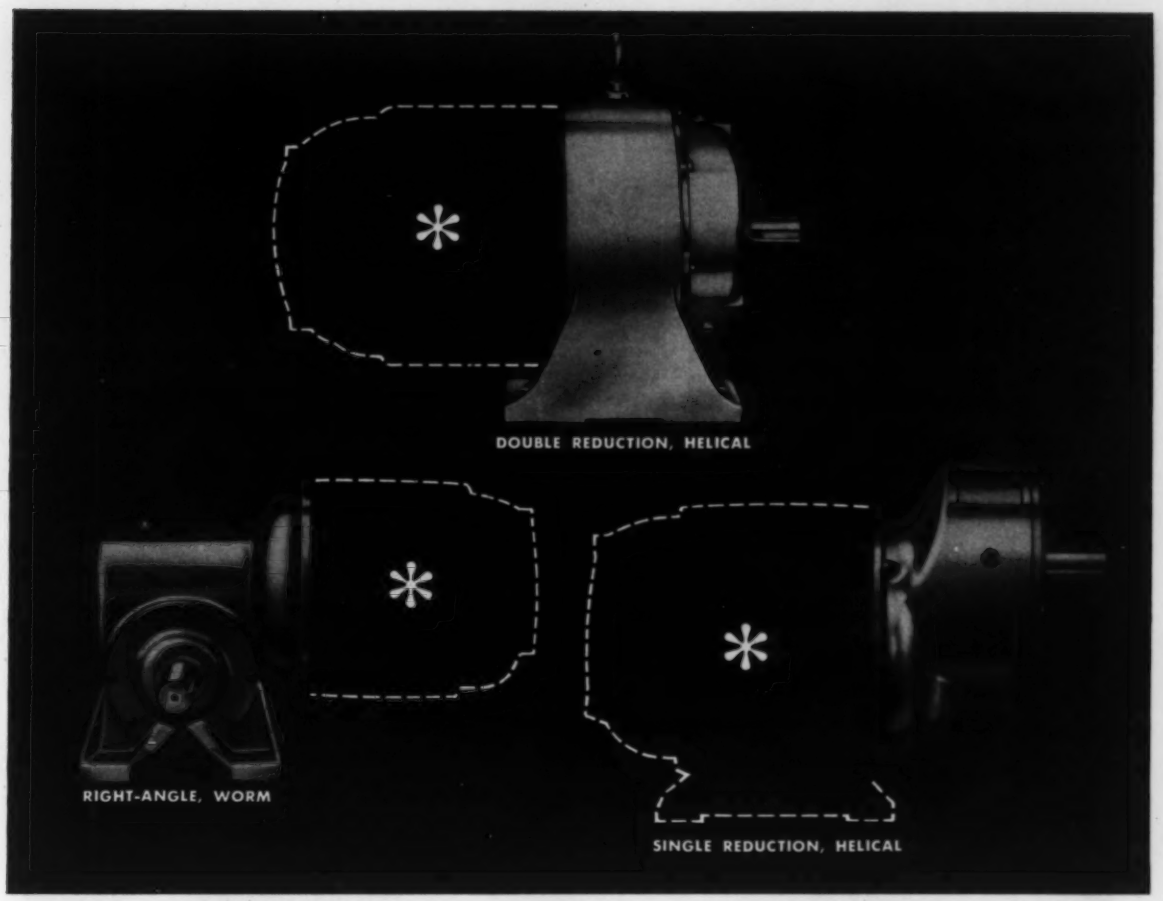
WRITE FOR COMPLETE INFORMATION

NEW 20-page catalog of Amweld Welded Precision Assemblies, Rings and Bands.

NEW booklet entitled, "HOW AMWELD FLASH BUTT-WELDED RINGS ARE PRODUCED".

THE AMERICAN WELDING & MFG. CO.
130 DIETZ ROAD • WARREN, OHIO

AMERICAN WELDING



Need a Motoreducer with an unusual drive motor?

LET REULAND TAILOR A MOTOREDUCER PACKAGE TO YOUR EXACT NEEDS . . .

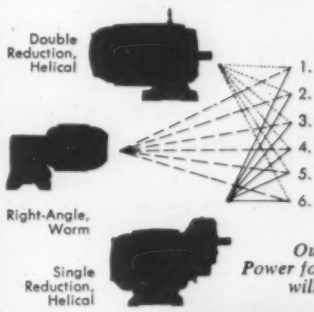
No longer must you "make something do" . . . no longer must you modify *your* machine to fit the *drive!* Hundreds of different speed and power variations can be developed from the three basic Reuland gear reduction units shown above.

This is made possible through the use of Reuland's famous "Xpandable-Design" idea.

Whether you need a simple motor-and-reducer – or an amazing, automatic combination with a special motor, gear reducer, magnetic brake and fluid coupling – Reuland engineers can quickly solve your drive problem.

Costs are lowered. Development time is saved. Your drive is *right*. Why not see first-hand what a Reuland Motoreducer can do for you.

*** ADD ANY ONE OF THESE 6 DRIVE MOTORS TO ANY OF THE 3 GEAR REDUCTION UNITS SHOWN ABOVE . . .**



Our new brochure "Modern Power for Modern-Day Products" will be helpful in your work. Sent free on request.

MODERN POWER FOR MODERN-DAY PRODUCTS
. . . ALL IN LIGHTWEIGHT ALUMINUM FRAMES!

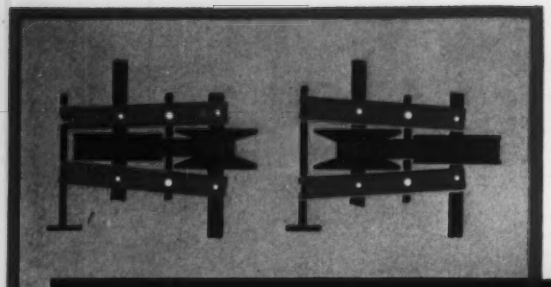
REULAND MOTORS

Reuland Electric Company — Distributors in all principal cities
Western Division: Alhambra, California • **Eastern Division:** Howell, Michigan

A DEMONSTRATION UNIT FOR YOUR EQUIPMENT?

So sure are we you'll like what you see, we're offering to engineer a demonstration unit for your equipment without the slightest obligation. Just write us.

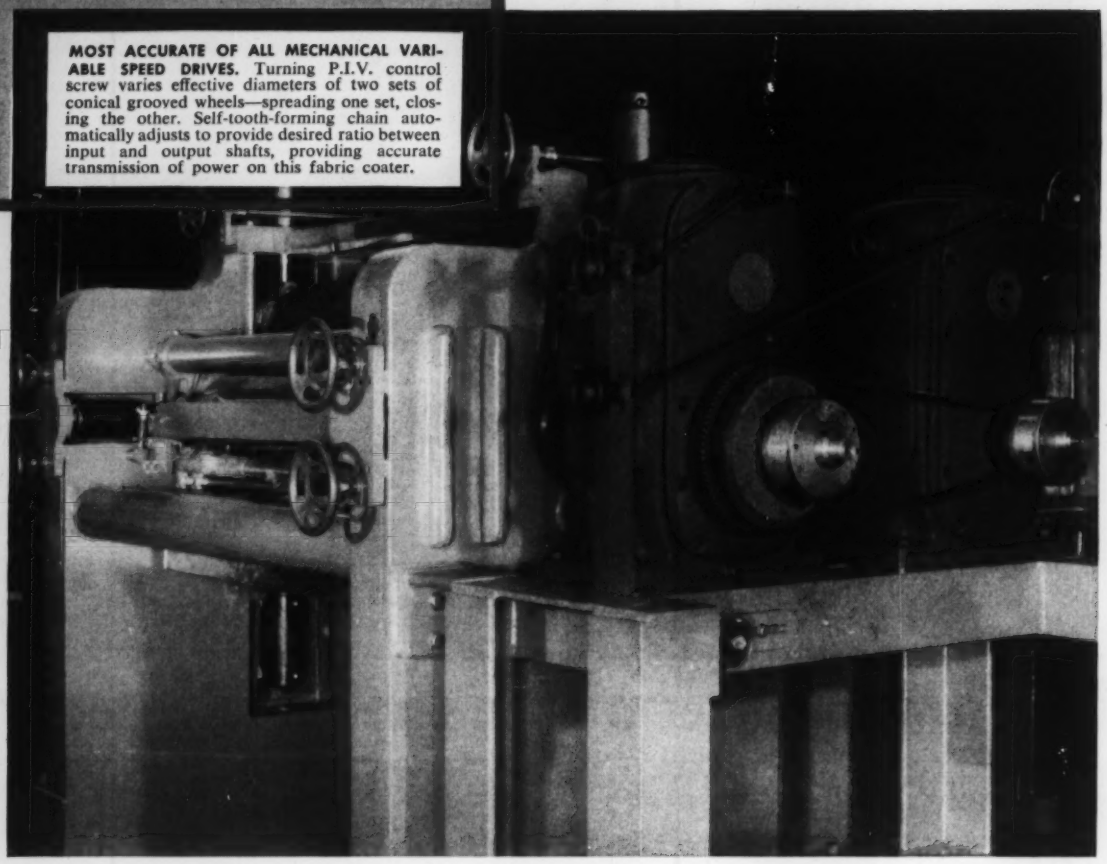
Circle 473 on Page 19



In principle . . .

in performance . . .

MOST ACCURATE OF ALL MECHANICAL VARIABLE SPEED DRIVES. Turning P.I.V. control screw varies effective diameters of two sets of conical grooved wheels—spreading one set, closing the other. Self-tooth-forming chain automatically adjusts to provide desired ratio between input and output shafts, providing accurate transmission of power on this fabric coater.



for positive, infinitely variable speed control

. . . there's nothing like P.I.V.

Here's a variable speed drive that is truly unique. Unlike conventional designs, Link-Belt P.I.V. with its all-metal chain drive is *not dependent on friction* for transmitting power.

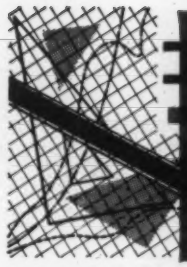
P.I.V. permits fast, easy speed changing too. You can select any speed in its range—find it instantly, hold it indefinitely. No bother stopping the drive.

Because Link-Belt P.I.V. (Positive, Infinitely Variable) drives are fully enclosed, atmospheric conditions can't affect their efficiency. They're made in 8 sizes, 16 standard types. Ask your nearest Link-Belt office for Book 2274.

LINK-BELT

P.I.V. VARIABLE SPEED DRIVES

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants and Sales Offices in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 14.842-A



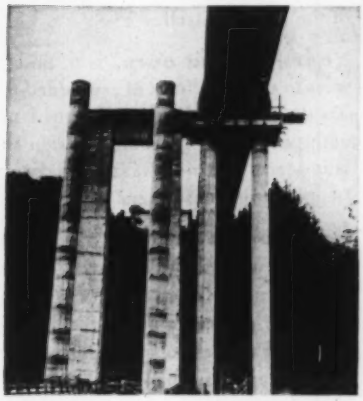
Molykote® DESIGN news

GERMAN ENGINEERS USE MOLYKOTE TO SLIDE 944 FOOT BRIDGE 60 FEET

The relocation of a bridge of these dimensions without the use of rollers has not previously been reported. The weight of the bridge was approximately 4,500 tons.

The results of extensive testing at the Bavarian Testing Institute at Nurenberg showed it to be more economical to move this bridge on girders lubricated with MOLYKOTE Type G than on rollers.

When writing refer to Item 503.



This bridge carries traffic of the Munich-Salzburg Highway over the Mangfall Valley.

MOLYKOTE® OPERATES EFFECTIVELY OVER -300°F. TO 750°F. TEMPERATURE RANGE

ATOMIC RADIATION DOES NOT AFFECT MOLYKOTE TYPE Z

Extreme temperatures rule out the the use of conventional lubricants. They freeze solid at extremely low temperatures or form objectionable deposits at elevated temperatures.

The missile age has further complicated lubrication problems. Not only must lubricants operate over a wide temperature range, but they must be unaffected by radiation, be capable of functioning in a vacuum, be compatible with liquid oxygen, and have indefinite storage life.

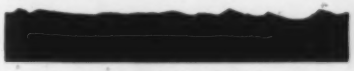
MOLYKOTE Type Z meets all of these requirements and is the only lubricant known to operate over a 1050°F. temperature range (-300° to 750°F.). In inert atmospheres, MOLYKOTE Type Z is unaffected by temperatures as high as 2000°F.

MOLYKOTE assures nearly 100% protection against galling and seizing on all low velocity extreme bearing pressure applications. With MOLYKOTE, the coefficient of friction decreases with increased loads and there is no tendency for it to be wiped away. The coefficient of friction with MOLYKOTE Type Z is .024 at 400,000 psi. MOLYKOTE maintains its effectiveness in the presence of all but a few strong acids. The problem of lubrication where abrasive dust contaminates the atmosphere is greatly reduced by MOLYKOTE dry films. MOLYKOTE Type Z conforms to MIL-M-7866A (ASG). It is the basic ingredient in the many MOLYKOTE types that are available to industry.

When writing refer to Item 501.

NEW MOLYKOTE "WEAR IN" COMPOUND REDUCES SURFACE DAMAGE RESEARCH PROVES

During the critical wear in period, permanent surface damage, variously described as "galling", "scuffing", "scoring", "tearing", "scratching", "excessive abrasion", and "seizing", is an inherent hazard.



Cross section of ground steel surface. (Redrawn to scale.)

When magnified, even highly polished metals show surface irregularities as in the drawing above.

MOLYKOTE "Wear In" Compound was developed as a result of extensive research. It drastically reduces the time necessary to accomplish wear in and eliminates the hazards.

"Wear In" damage requires costly reconditioning of new equipment and the amount of damage left unrepaired has much to do with the useful service life of machinery.

When writing refer to Item 502.

LIFETIME LUBRICATION WITH MOLYKOTE BONDED COATINGS

MOLYKOTE resin bonded lubricant coatings combine all the outstanding characteristics of MOLYKOTE with today's most advanced air-drying and thermosetting resins.

Roller Bearing Company, W. Trenton, N. J., process self-aligning bushings with a MOLYKOTE resin bonded coating. This coating provides lifetime lubrication and protection against corrosion.

MOLYKOTE resin bonded lubricant coatings are an amazing new development in the field of lubrication. They provide bearing surfaces with a wear-resistant film that has a low coefficient of friction. In many cases, the initial treatment is sufficient to lubricate parts for the lifetime of the equipment.

When writing refer to Item 504.

Self-aligning bushing manufactured by Roller Bearing Corporation of America, W. Trenton, N. J.

THE ALPHA-MOLYKOTE CORP.,
Stamford, Conn.
Please send me details on

Item 501 ☐ Item 502 ☐
Item 503 ☐ Item 504 ☐

SEE OUR CATALOG IN SWEET'S PRODUCT DESIGN FILE

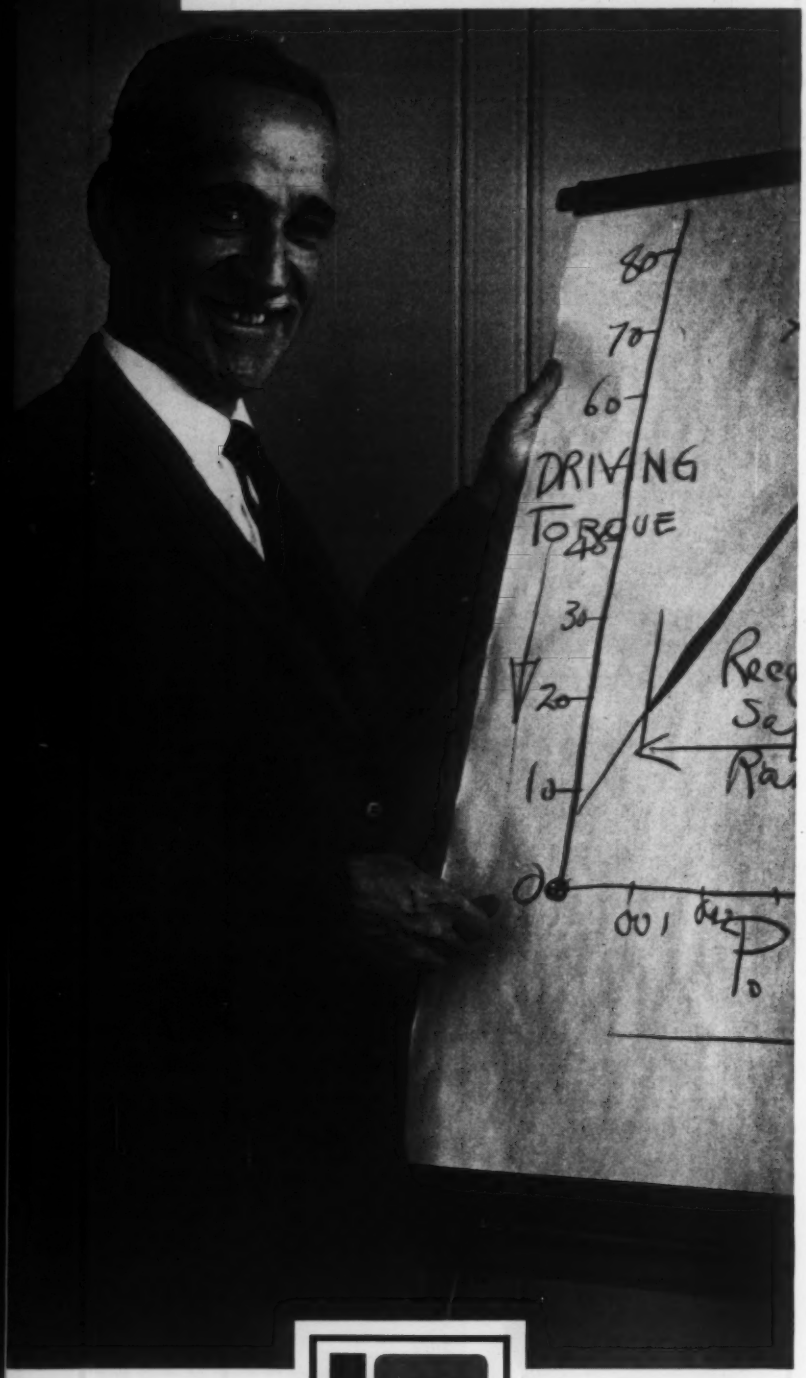
Name _____
Company _____
Address _____
City _____
State _____

Address your letter to The Alpha-Molykote Corp., 65 Harvard Ave., Stamford, "Research City", Conn. Phone: FIreside 8-3724.

BREAKING LUBRICATION BARRIERS ...THROUGH RESEARCH

Circle 475 on Page 19

WILLIAM G. WALTERMIRE, *Chief Products Engineer, Lamson & Sessions, says...*



Your interest... and ours... is "assembled product cost"

Many fastener users think only in terms of unit price. Actually, labor costs of assembly are usually 3 to 4 times the price of the fastener itself.

Your job, and ours, is to find practical ways to cut your "cost of assembled product". To do this, we frequently hold meetings with purchasing personnel, design engineers, standards engineers, and quality control people at our customers' plants.

By means of charts and slides, we show how to simplify types and sizes of fasteners used, which reduces purchasing and inventory costs. We guide them in selection of thread classes to meet different material, tapping and assembly problems. We often suggest ways to improve strength and cut costs—by substituting a smaller high carbon fastener for a larger size, low carbon type. Or we may suggest redesign of a bolted assembly to use standard instead of special fasteners.

Take advantage of this no-charge L & S service. Call or write us for an analysis of *your* fastener problems.

L & S Fastener Engineering helps you "tighten up" on...

- **PURCHASING COSTS**
- **INSPECTION AND HANDLING COSTS**
- **ASSEMBLY COSTS**

LAMSON & SESSIONS

5000 TIEDEMAN ROAD • CLEVELAND, OHIO

Plants in Cleveland and Kent, Ohio • Chicago and Birmingham

Circle 476 on Page 19

MACHINE DESIGN
April 2, 1959

A Premium for Competence

REMEMBER when the "shortage of engineers" was a burning issue? Remember, too, how some engineers complained that their salaries didn't seem to respond as they should have if the law of supply and demand had been at work?

There is a possible explanation. Widely published salary figures, reported as averages or medians, seemed to support such a view. But they did not reflect what was happening in the upper brackets. The latest Engineers Joint Council report on *Professional Income of Engineers in* 1958, read in conjunction with the earlier 1953 and 1956 reports, tells the story.

In actual fact, median salaries did increase substantially over the five-year period. More significantly, the percentage increases were perceptibly greater in the upper salary brackets. In other words, the spread between median and higher salaries is increasing.

Another characteristic differentiates the median and lower-bracket engineers from the upper-bracket group. After about twenty years of service, median salaries are about equal for all engineers, regardless of length of service. The same is true of the lower brackets. But among upper-bracket engineers longer service is reflected in higher income.

Encouraging conclusions can be drawn. The competent, effective engineer who continues to grow on the job throughout his working life is being suitably rewarded. The merely adequate, and even the mediocre, engineers are making a good living. But they are not being overpaid to the extent that they might deprive their more effective colleagues of well-earned advancement.

The shortage of quality—which was the only real shortage—did affect salaries exactly as the law of supply and demand could have predicted. Talent and competence can always command a premium.

Colin Carmichael

EDITOR

MEASURING MOTION with HIGH-SPEED MOVIES

. . . What available cameras can do

. . . How to get data off the film

. . . Determining the accuracy of the data

By WILLIAM G. HYZER
Consulting Research Engineer
Janesville, Wis.

SLOWING down high-speed motion with a movie camera is often referred to as time magnification. The technique is simple. Movies of an object under study are taken at high speed and projected on a screen later at slow speed.

If an action of 1 second duration is photographed at a picture frequency of 3200 frames per sec, a sequence of 3200 individual pictures will be obtained, each depicting an incremental stage in the progressive phases of the action. When these pictures are thrown on the screen at a normal projection frequency of 16 frames per sec, the entire sequence will be stretched to 200 sec. Velocity of motion will be slowed down by a factor of 200. The result is a time magnification of 200 to 1.

High-Speed Cameras

There are several excellent 16-mm high-speed cameras designed specifically for this motion-analysis work. These include the Fastax (Fig. 1), the Fairchild Motion-Analysis camera, the Photo-Sonics Inc. camera, and the Beckman and Whitley Dynafax and Magnifax.

The Magnifax camera operates at speeds from 300 to 3000 frames per sec. The new Fastax operates at speeds to 9000 pictures per second while the new Dynafax goes to 25,000 16-mm frames per second.

These cameras depend on a rotating prism located between the lens and the film plane to compensate for image movement during the brief exposure cycle of each frame. Light from the lens to the image is refracted by the rotating prism in accurate synchronism with the continuously moving film to produce a blur-free image. Picture frequency required to stop motion is determined by:

$$F = \frac{0.4\,K\,V\cos\phi}{W\,B} \qquad (1)$$

As a general rule, image blur B should not exceed 0.002 to 0.003 in.

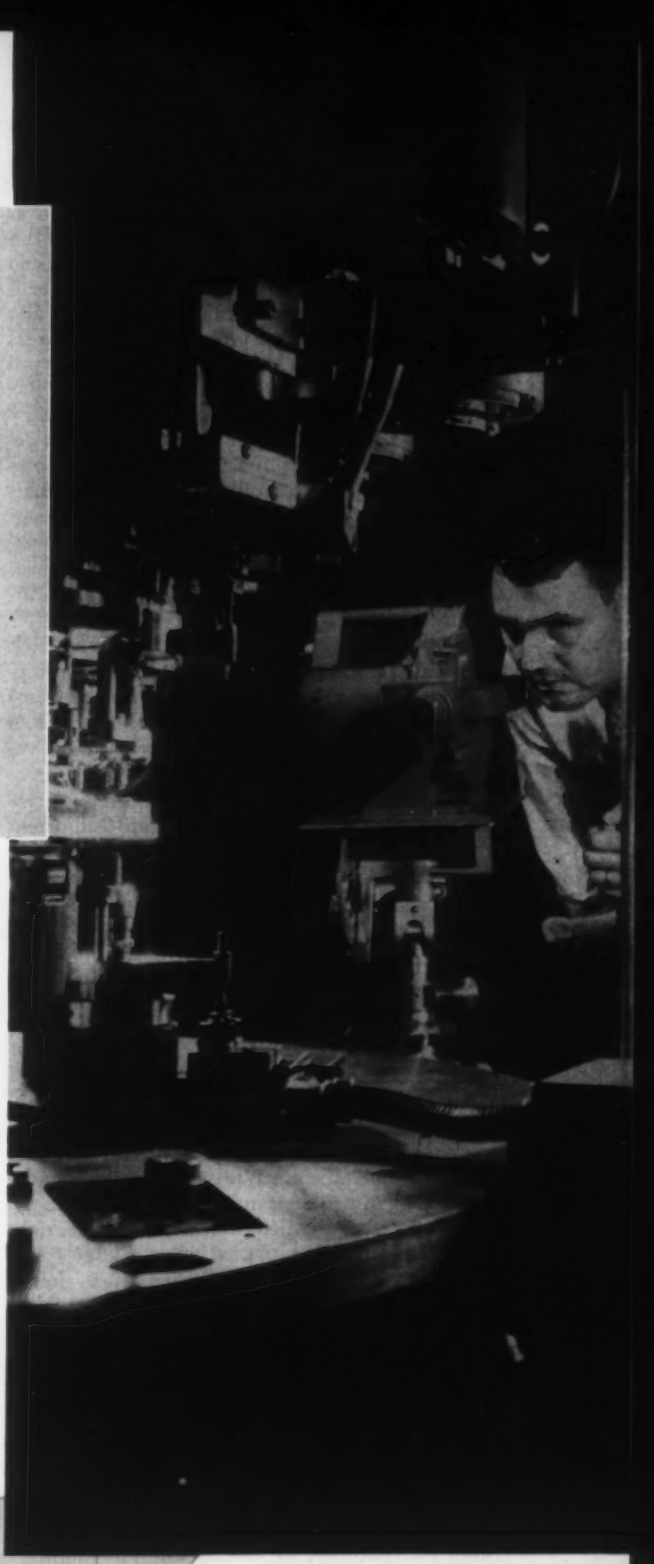
Film velocity through the camera is not constant, but at the higher camera speeds is continuously accelerating until the end of the film is reached.

Time interval between frames is determined by exposing timing marks on the edge of the film with light pulses generated at a known frequency. The timing lamp for producing these pulses is an integral part of commercial cameras and consists of a neon lamp fired by an external 60-cycle source or an oscillator of controlled frequency. Ordinary

Why Use High-Speed Movies?

- *To obtain development data.*
- *To troubleshoot preliminary design.*
- *To check final performance.*

Besides "slowing" time to let the eye see the action, high-speed movies can be analyzed, frame by frame, to yield accurate measurement of time, displacement, velocity, acceleration.



60-cycle sources are usually accurate to within 1 per cent. Crystal-controlled oscillators are stable to within several parts per million per deg C. More information on the operational characteristics of high-speed movie cameras is given in References 1 and 2 (tabulated at end of article).

Film-Analysis Techniques

The general field of high-speed movie analysis can be dissected into two distinct categories—qualitative and quantitative. The first is simply visual observation of the projected image. The latter

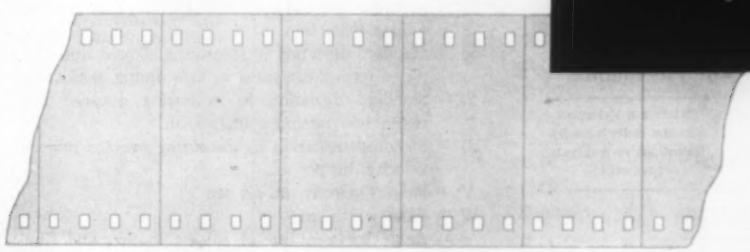


Fig. 1—Typical setup of high-speed movie camera and lighting for photographing rapid machine motion

deals with the mathematical methods by which numerical data are obtained from the film image.

This latter technique is commonly referred to as micromotion analysis. Probably 90 per cent of industrial high-speed films are intended for visual analysis of the projected image. Examination is facilitated by using a reversible projector which can also be stopped for single-frame projection. Critical areas of the film can be run back and forth or stopped for detailed study.

Visual analysis places the entire responsibility for analytical judgment upon the human eye, a device which is largely influenced by variable psychological and physiological factors. Several characteristics of the visual process limit its effectiveness as an analytical instrument. Table 1 compares the minimum percentage instantaneous change in velocity that can be detected by visual and by quantitative methods.[3]

In contrast to visual analysis, quantitative methods make use of dimensional-change measuring equipment to determine image displacement from frame to frame and corresponding time intervals. From these data, measurements can be obtained on velocity, acceleration, actuation time, etc.

The optical comparator, the measuring microscope, and even photographic projection equipment can be effectively adapted for measuring dimension changes on movie film, depending upon the accuracy of the required results, permitting measurements on the film to within 0.0002 in. Conventional or modified projection equipment does not ordinarily produce accuracies on this order of magnitude, but may be found useful when the ultimate in precision is not required.

Optical Comparator: Adaptation of the comparator and microscope to the measurement of photographic images usually involves nothing more than keeping the film in a fixed position within the optical field of the instrument. With the comparator, the stage holding the film is normally moved through the field by two vernier screws located at right angles. The image is projected upon a large translucent screen where cross hairs are imprinted. Image position is determined by reading two verniers when the image is correctly aligned with the cross hairs. The film should be maintained flat on the stage of the instrument by sandwiching it between two pieces of glass.

Microscope: The measuring microscope is usually designed with a graduated reticle in the eyepiece.

Table 1—Sensitivity of Motion-Analysis Method

Number of Frames Devoted to Action	Minimum Velocity Change Detectable by Eye (per cent)	Minimum Velocity Change Detectable by Quantitative Analysis (per cent)
40 or more	10	½
30	15	½
20	30	⅞
10	60	2

Fig. 2—Projector specially designed for measuring incremental changes of position of mechanism parts recorded on successive frames of movie film. Vernier-driven cross hairs, which are directly connected to readout counters, can be positioned to an accuracy of 0.001 in. on the screen or 0.0001 in. relative to film dimensions

Nomenclature

B = Image blur, in.
D_o = Object distance, in.
D_t = Distance between timing marks, in.
E = Absolute error in measuring the distance between two objects, in.
F = Picture frequency, frames per sec
K = Camera shutter constant (0.6 for Fairchild and Fastax, and 0.3 for Kodak)
L = Focal length of lens, in.
M = Image magnification
N = Number of frames in sequence to be analyzed
S_d = Standard deviation of individual measurements of distance between timing marks, in.
S_i = Standard deviation in measuring cross hair alignment with an image, in.
S_m = Standard deviation in measuring the distance between a stationary and moving object in the subject field, in.
S_o = Standard deviation in measuring the distance between two sharply defined objects in the subject field, in.
S_p = Standard deviation in measuring elapsed time between frames bracketed by two timing marks, sec
S_r = Standard deviation in measuring distance between two reference images, in.
S_v = Standard deviation in measuring average subject velocity, in. per sec
V = Subject velocity, in. per sec
W = Field width, in.
ϕ = Angle between line of subject motion and film plane, deg

In this case, the film is mounted on the stage of the microscope between glass to maintain flatness. The proper magnification is chosen for the particular image to be analyzed. It is usually necessary to calibrate the reticle for the specific magnification employed. Field coverage of the microscope limits the efficiency of this system for film analysis. Only at exceedingly low magnification can the entire 16-mm frame be observed.

Projector: Film measurements, using conventional photographic projection equipment, are accomplished by projecting the image onto a screen, either reflecting or preferably translucent, where the image dimensions can be scaled off. Care must be taken to align the screen accurately, perpendicular to the optic axis of the lens. A translucent screen observed from the side opposite the projector is most convenient to use.

Film-Motion Analyzer: A convenient film-measuring instrument is a film-motion analyzer designed specifically for this application, Fig. 2. In an instrument of this type, film can be either manually or automatically transported. The equipment utilizes movable cross hairs on a translucent viewing screen, and a rotatable projection head for obtaining accurate linear and angular measurements.

▶ Film-Analysis Equipment

Reduction of dimensional and time data from the motion-picture film is a straightforward operation permitting both accurate and rapid analysis. The analyst has a choice of several procedures depending upon the nature and quantity of the film data, the analytical equipment available, and the accuracy requirements.

The first step is to view the films either on a screen or in an editor and pick out the sequence of frames to be further analyzed. The first and last frames in the sequence are usually notched or otherwise marked for ready identification. Then the position of the timing mark corresponding to the first and last frames in the sequence should be marked on the film edge. With the Fastax camera in Fig. 1, the timing mark precedes the photographic image by 5 frames. In the case of the Eastman High-Speed camera, the timing mark is 10 frames following the photographic image.

As the next step, image displacement in each successive frame is measured by the use of a suitable reading device and data are listed as shown in the second and third columns of the table in Fig. 3. Additional columns can be provided for tabulating the Y co-ordinates of displacement data and the X and Y co-ordinates of other actions evident in the films. In this example, a stationary reference mark is included in the tabulation in addition to the co-ordinate points determined by the trajectory of the motion under investigation. Subtracting the X co-ordinates of the reference point from the X co-ordinates of motion compensates for any error introduced by camera movement or by bounce and weave of the film through the camera.

Scale Factor: At this point, image-displacement data are converted to actual object-space dimensions by multiplying by a scale factor. This factor is equal to the reciprocal of the image magnification. It is obtained by measuring the image distance between the leading edges of two objects separated by a known distance or less accurately by calculation based on lens focal length and object distance:

$$M = \frac{D_o - L}{L} \qquad (2)$$

Significant error may be introduced if the overall image size of a known object is measured to determine magnification. This effect is treated in the section on absolute-distance errors.

Data Reduction: The next step in the analytical

Frame No.	X Co-ordinate of Moving Image (in.)	X Co-ordinate of Stationary Image (in.)	X Co-ordinate of Image Displacement (in.)	X Co-ordinate of Object Displacement (in.)	Elapsed Time (millisec)
1	0.1437	+0.0001	0.1436	0.4308	0.00
2	0.1430	+0.0001	0.1429	0.4287	0.15
3	0.1424	-0.0001	0.1425	0.4275	0.30
4	0.1418	-0.0002	0.1420	0.4260	0.45
5	0.1413	+0.0001	0.1412	0.4236	0.59
6	0.1406	-0.0003	0.1409	0.4227	0.74
7	0.1401	+0.0001	0.1400	0.4200	0.89
8	0.1445	+0.0003	0.1442	0.4326	1.03
9	0.1438	-0.0001	0.1439	0.4317	1.18
10	0.1433	0.0000	0.1433	0.4299	1.33
71	0.0257	+0.0002	0.0255	0.0765	9.45
72	0.0172	-0.0001	0.0173	0.0519	9.60
73	0.0086	0.0000	0.0086	0.0258	9.74
74	-0.0001	-0.0001	0.0000	0.0000	9.88
75	+0.0001	+0.0001	0.0000	0.0000	10.12

Fig. 3—Typical method of tabulating image - displacement data from successive frames of a high-speed movie film

procedure is the determination of time intervals between frames. This is usually expressed as total elapsed time from frame zero to the frame number under study. In other words, frame zero corresponds to zero time. Starting with zero time point, the linear distance to each successive timing mark is determined and the data tabulated as shown in Fig. 4. The first column of the tabulation in Fig. 4 gives the total elapsed time between timing marks, starting with the first timing mark beyond zero time point. The time interval between successive marks is determined by the frequency of the light pulses from the timing lamp. The second column in Fig. 4 shows the linear distances between the first timing mark and each consecutive time interval listed in the first column. Column 3 is a tabulation of timing-mark distances in frame units. These data are obtained by dividing the values in Column 2 by the pitch of the film, which in this case equals 0.3 in. These data are now ready for graphical presentation.

Total-elapsed-time values from Column 1 in Fig. 4 are plotted as ordinates and total timing-mark distances in frames from Column 3 as abcissas in Fig. 5. This curve relates total elapsed time with frame number. Time values from the curve are shown in Column 4 of the table in Fig. 3. Columns 2, 3, and 4 in Fig. 3 relate total elapsed time with total image displacement. These data can be further differentiated to determine acceleration and velocity.

Time Calibration: Ordinarily, it is unnecessary to use a film reader to process timing-mark data. An accurate 36-in. steel rule with 1/64-in. graduations is satisfactory for this job. The film strip is laid down on a flat, light-colored or transparent surface so that the marks are clearly visible. If the end of the scale is positioned with the zero time point on the film, the timing mark distances can be read quickly and accurately.

Absolute duration and velocity measurements can be obtained only when the period between successive frames can be found in absolute time units. Relative velocities, accelerations, and time intervals can be determined without any knowledge of the exact period between frames. In this case, all the analyst needs to know is the rate at which the picture frequency is changing throughout the film strip being analyzed. If the film strip consists of only a few frames, the period between frames can be assumed constant. The maximum time variation between consecutive frames exists at the beginning of the film, within the first 20 ft, where the acceleration through the camera is the greatest.

If it is assumed that the picture sequence to be analyzed is not part of this starting transient, the greatest time variation that will ordinarily be encountered is about 0.05 per cent per frame. This means the period between successive frames will decrease a maximum of ½ per cent in ten frames or 5 per cent in 100 frames.

If an accuracy of ±1 per cent is adequate, and the picture sequence consists of 40 frames or less and is not part of the starting transient, it is safe to assume a constant time duration between frames. For an accuracy of ±½ per cent, the same assumption can be made for a strip consisting of 20 frames or less.

When more than 40 frames are to be analyzed, or if the sequence is taken from the first 20 ft of film, it will usually be necessary to correct for time variation between frames.[3]

Measurement Errors

The overall dimensions of a 16-mm film frame are 0.3 by 0.4 in. Experience has demonstrated that the minimum practical standard deviation, S_i, of individual measurements in defining the edge of a sharp, high-contrast image is ±0.0001 in. Actual values may exceed this value by 2 to 3 times if the image quality is not optimum. According to statistical theory, 68 per cent of all individual measurement readings will be within one standard deviation of the mean, 95 per cent for two, and 99.7 per cent for three.

Error is greater for blurred images as expressed in the following equation:

$$S_i = B(7.5 \times 10^{-3}) + 10^{-4} \qquad (3)$$

Image sharpness is dependent upon several factors: 1. Resolving power of the optical system. 2. Resolving power of the photographic emulsion. 3. Accuracy with which the lens is focused on the subject. 4. Degree of image blur caused by subject or camera movement during the interval of exposure. Nature of the image is determined by the characteristics of the subject photographed. Factors that are important from a measurement standpoint are contrast of the subject and sharpness of the lines or edges to be measured on the subject.

Random-Distance Error: Reproducibility of measurement is influenced appreciably by the contrast

Total Elapsed Time (millisec)	Timing-Mark Distance (in.)	Timing-Mark Distance (frames)
1	2.126	6.753
2	4.054	13.513
3	6.086	20.286
4	8.121	27.071
5	10.159	33.864
6	12.199	40.664
7	14.244	47.479
8	16.292	54.305
9	18.341	61.135
10	20.394	67.979
11	22.450	74.833

Fig. 4—Typical tabulation of timing data taken from high-speed movie film

and sharpness of the reference lines on the subject. Measurement accuracy is improved by using sharp, high-contrast lines if care is taken not to overexpose the highlights and cause bleeding into the underexposed regions.

A 30 per cent increase in measurement accuracy is obtained by using a high-contrast reference line painted on a typical object to be measured.[4] Optimum reference-line width is about 0.006 in. in terms of image dimensions or 1 to 2 per cent of the subject field width, W. Minimum practical standard deviation of individual measurements of distance between two reference lines is $S_r = \pm 0.00014$ in.

The standard deviation in measuring the distance between two sharply defined objects in the subject field is given by

$$S_o = \pm 35 \times 10^{-5} W$$

Again actual measurements may exceed this value by a factor of several times if image quality is poor.

As previously stated, a stationary reference within the field of view is normally recommended. Minimum standard deviation in measuring the distance between a stationary line and a blurred moving reference line in the object space is:

$$S_m = 10^{-4} \sqrt{12.5W^2 + 187\frac{WKV}{F} + 5600\left(\frac{KV}{F}\right)^2} \quad (4)$$

Absolute-Distance Error: When attempting to measure the position or size of a blurred image, an absolute error is introduced in visually determining the exact edge of the image. An observer will normally bisect the area of blur with the cross hairs to locate the apparent edge of the image. Because of a nonlinear density gradient across the blurred area, however, the actual midpoint of blur does not coincide with the apparent midpoint. The effect becomes negligible for blur less than 0.001 in. It may be significant in many practical cases where the blur exceeds this value, particularly when measuring motions of changing velocity such as a vibrating spring.

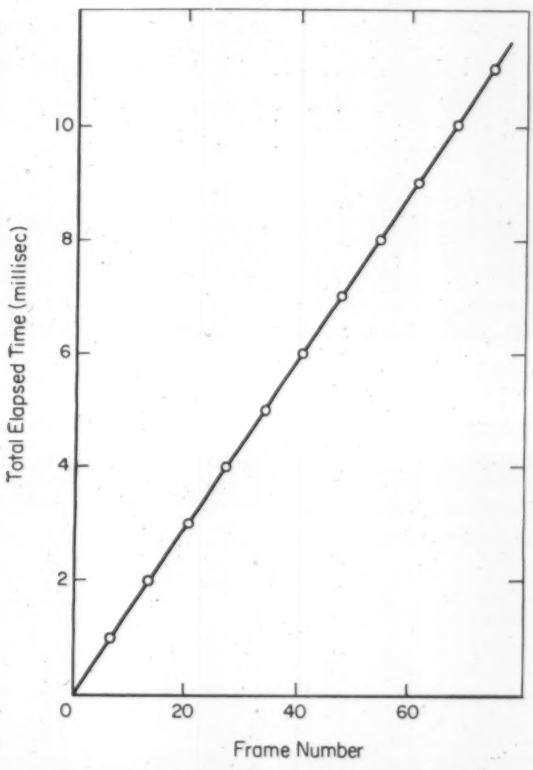


Fig. 5—Time-calibration curve for correcting camera-acceleration characteristic. Data are obtained from Columns 1 and 3 of table in Fig. 4

Table 2—Dimensional Stability of Cellulose Triacetate Base

	Change in Film Width (per cent)	Change in Film Length (per cent)
Processing Shrinkage	0.06	0.07
Humidity Expansion, at 10 per cent rel. humid.	0.07	0.08
Thermal Expansion, at 20 C.	0.06	0.07
Aging Shrinkage in 1 yr at 78 F and 60 per cent rel. humid.	0.16	0.13

As an example, suppose the vibration of a spring is being analyzed. It oscillates in simple harmonic motion at a frequency of 50 cps and with an overall amplitude of ½ in. This spring is photographed using a field width of 1 in. at a picture frequency of 2000 frames per sec. Absolute measurement error caused by image blur will result in a distortion component that is 90 deg out of phase with the primary wave and has an amplitude 4 per cent of the amplitude of the primary vibration to be measured. Correction for this error in measuring the distance between two identical reference lines is obtained by adding one-half the difference between the measured widths of the two lines to the measured distance between the leading edges of the two lines. This introduces additional random error, but it is a necessary compensation in cases of excessive blur.[5]

Typical absolute error in measuring the distance between a blurred, high-contrast moving object and a stationary reference object is given by

$$E = \pm\left(0.46\frac{KV}{F} - 1.25 \times 10^{-3} W\right) \quad (5)$$

This equation is void if the value within the brackets becomes negative. Absolute error is positive for a black image moving away from the reference image or a white image moving toward the reference image. Absolute error is negative for a black image moving toward the reference image or a white image moving away from the reference image.

Distortional Error: Other absolute errors in measuring image position are introduced by dimensional instability of film and optical-distortion effects. Shrinkage characteristics of film[6] are shown in Table 2. Typical optical distortional errors for high-speed cameras[4] are only about 1 per cent vertically and ¼ per cent horizontally.

The fact that shrinkage and optical distortion are directional effects emphasizes the importance of including a suitable scale in the field of view, parallel

and in close proximity to the object path. Optical distortion is least in the center region of the film frame and is negligible for horizontal motion with an amplitude less than 5/8 of the field width.

Time Error: Standard deviation of average elapsed time between any two frames bracketed by two timing marks is

$$S_p = \frac{(N-1)S_d}{FD_t} \qquad (6)$$

A typical value of S_d using a 60 cps light source and a Fastax camera at 1000 frames per sec is $\pm 5 \times 10^{-3}$ in.

Error in measuring the duration of an action that is observed commencing on one frame and terminating on a latter frame is roughly $\pm 1/F$.

Velocity and Acceleration Errors: Random error in measuring velocity, S_V determined by total object movement between any two frames is given by

$$S_V = \pm \frac{F}{N-1}\sqrt{2S_m^2 + S_p^2V^2} \qquad (7)$$

Instantaneous velocity is obtained by measuring the image displacement during the time interval between two successive frames. In this case, N in the above equation equals 2.

Practical tests run by the University of California Institute of Transportation and Traffic Engineering using combined graphical and analytical methods have shown that an accuracy of $\pm$ 1 per cent is attainable in the measurement of acceleration.[7]

Example Problem

Determination of the actuation characteristics of a small solenoid is illustrative of a typical application of micromotion analysis using high-speed cinematography. Assume that the solenoid is set up to trigger two precision snap-action switches in sequence. The actuation time and maximum armature velocity are critical to its effective operation. Velocity must not exceed 100 in. per sec over any 1 millisec interval. Black reference lines are painted on the armature and the stator against a white background. Relative movement between the stator and armature will be measured and plotted relative to elapsed time to obtain the required data.

Total armature movement is 0.440 in. Actuation time is estimated at 10 to 15 millisec. Value of maximum velocity is 100 in. per sec. A 500 cps oscillator is used as a time standard. Based on Equation 1 and an estimate of solenoid velocity characteristics, camera frequency is determined. A speed of 6500 frames per sec at a field width of 1.2 in. is chosen for $K = 0.6$ and $B = 0.003$ in.

By the process of counting individual frames, actuation time can be estimated to within $\pm 1/F$ or ± 0.15 millisec. Greater accuracy can be obtained from the time-displacement curve. From Equation 4, $S_m = 9 \times 10^{-4}$ in. From Equation 5, $S_p = 2.4 \times 10^{-6}$ sec, based on $S_d = 5 \times 10^{-3}$ in. Random error in determining velocity, S_v, is obtained by the use of Equation 7 and equals 1.3 in. per sec. Therefore, at the 100 in. per sec velocity level, there is 95 per cent confidence that random-measurement error in determining average velocity over a six-frame interval will not exceed $2S_V$ or 2.6 per cent. At the 99.7 per cent confidence level, error will not exceed $3S_V$ or 3.9 per cent.

Displacement and time data are shown in Fig. 3 and 4. A time displacement curve is drawn in Fig. 6. From this curve, actuation time is found to be 11.2 millisec and maximum velocity to be 198 in. per sec. Measurement error can now be recalculated using the more accurate data from the curve.

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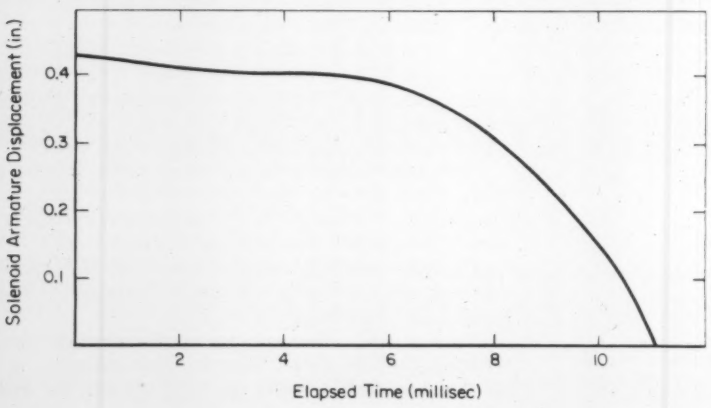

Fig. 6—Time-displacement curve of solenoid armature plotted from high-speed movie films. Curve shows armature was actuated in 11.2 sec

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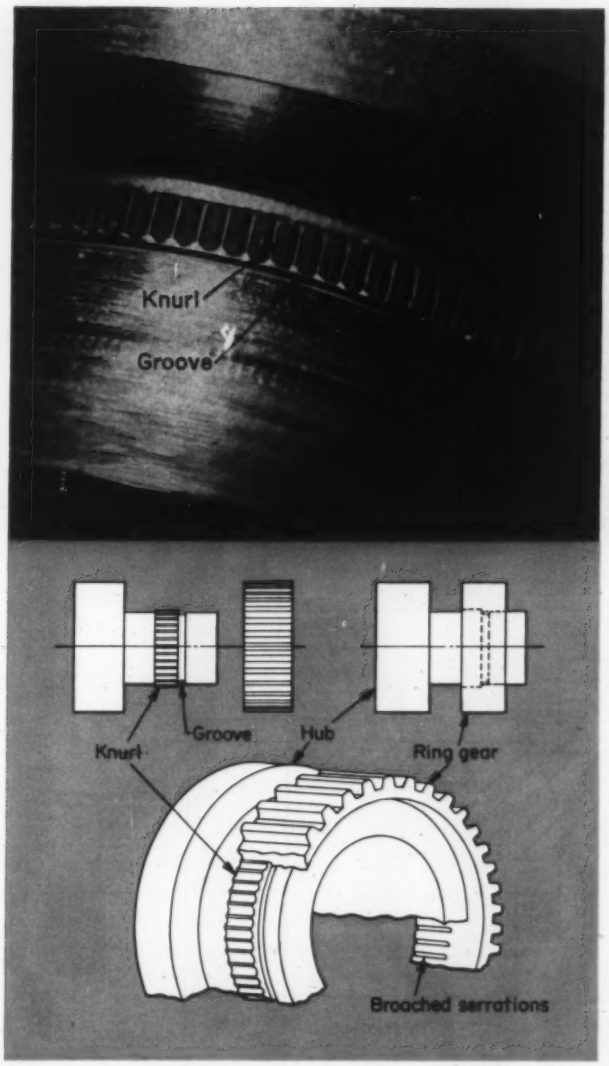
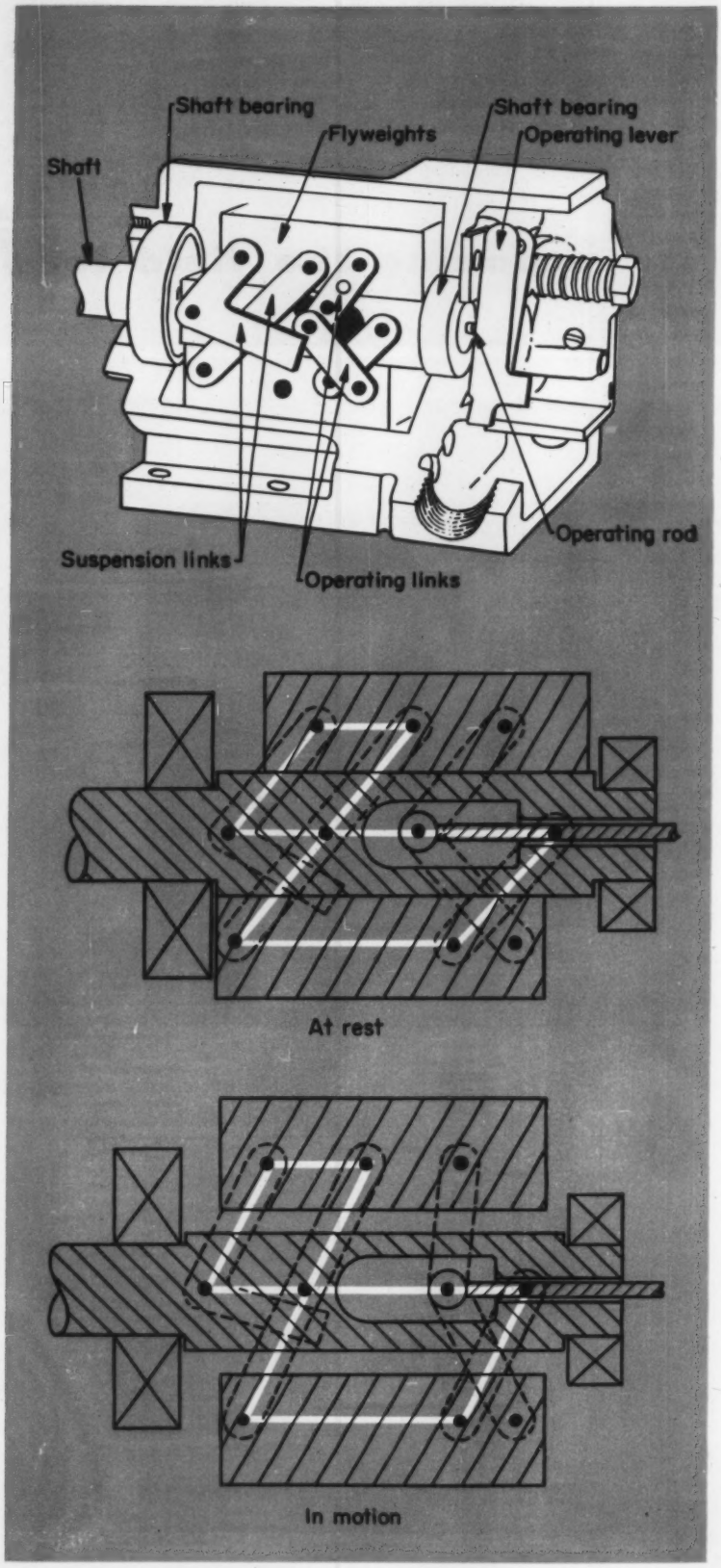
scanning the field for *ideas*



"Knurl"-broached surfaces provide an effective means of joining miniature precision components with dimensions too small to permit use of normal fastening devices. Developed by Willard J. Opocensky, Librascope Inc., this principle is used to fasten ring gears to bevel-gear hubs in a miniature differential. A fine-pitch knurl, which slightly increases the hub diameter, is applied to the hub surface. The pitch of the knurl depends upon the load to be transmitted, while the width of the knurl is slightly less than half the width of the ring gear. After knurling, a groove is machined around the hub at the leading edge of the knurl. This chip groove cuts across the ends of the knurls and forms sharp edges which act as tiny broaching teeth. As the ring gear is pressed onto the hub, the groove collects the material removed from the ring gear, and prevents galling and spalling of the metal. The gears can be removed, the chip groove cleaned, and another gear pressed on. Where a permanent fit is required, the gear is staked into position.



Dual four-bar linkage permits development of full flyweight action within a confined space. A pair of scissor linkages on either side of a square shaft section are attached to a pair of flyweights and, through a common pivot, to an oversized pin which passes through a hole, perpendicular to the drive axis, in the shaft section. The flyweights are attached to the shaft with supporting links. The weights move in parallel paths due to the action of the supporting links. Motion of the operating rod is a function of the combined linear and radial motions of the weights. This principle is used in a centrifugal switch developed by Euclid Electric and Mfg. Co.

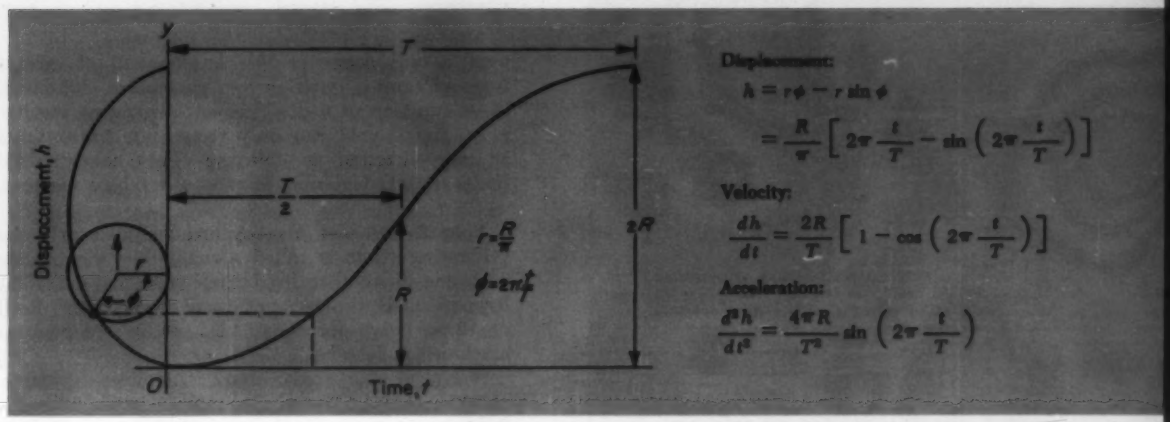


Fig. 1—Basic cycloidal motion relationships. Acceleration is a function of the sine of an angle that varies from 0 to 2π as t varies from 0 to T

Looking for a way to get intermittent or irregular motion with

—Smooth drive-acceleration characteristics?
—High inertia-load capacity?
—Variable stroke or displacement?

Best answer may well be one of the

Cycloidal-Crank Mechanisms

By E. H. SCHMIDT, Senior Mechanical Consultant, Mechanical Development Laboratory
E. I. du Pont de Nemours & Co., Wilmington, Del.

INTERMITTENT motions and variable velocities are the cause of inertial forces that often limit the productive speed of a machine. In the study of this problem, considerable information has been developed on the dynamic behavior of different types of cams, Genevas, and four-bar linkages. But surprisingly little attention has been given to the various forms of mechanisms employing cranks with cycloidal, epicycloidal, or hypocycloidal displacements.

Many unique and useful motions can be generated by these devices. In addition, their dynamic operating characteristics and load-carrying capacities are ideally suited for high-inertia applications.

Basic Cycloid Form: A displacement with full sine curve acceleration characteristics can be generated directly from a cycloid, Fig. 1. The displacement curve is obtained by rolling a circle, which has a circumference equal to required displacement $2R$, along the y axis and projecting the y co-ordinate of a point on the circle with respect to equal increments of time t along the x axis. Time increment t is proportional to the angular rotation of the circle.

Cycloidal-motion relationships, Fig. 1, have been

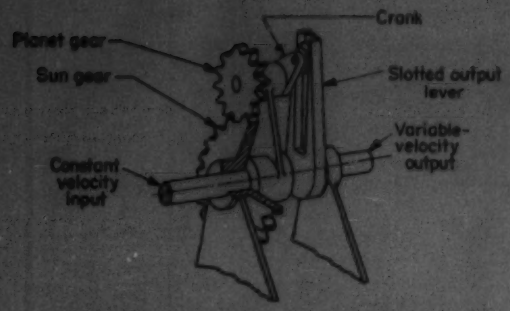


Fig. 2—Typical epicycloidal-crank mechanism. Hypocycloidal design is basically the same except that a fixed internal, rather than external, gear is employed

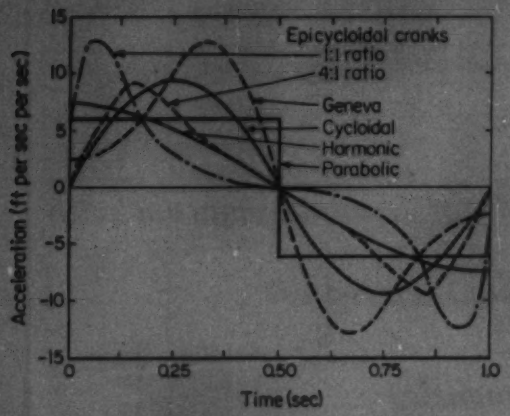


Fig. 3—Comparison of acceleration characteristics for different generated motions

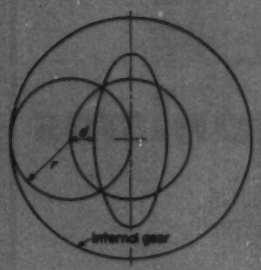


Fig. 4—Hypocycloidal-crank with 2:1 gear ratio for generation of elliptical motion path. As d varies from 0 to r, the ellipse generated by the crank varies between its limits of a circle and straight line. This principle can be used to obtain an adjustable, variable-stroke mechanism by rotation of the internal gear

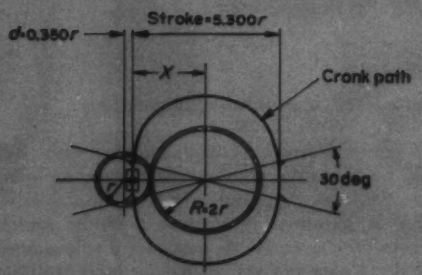


Fig. 5—Epicycloidal crank with 2:1 gear ratio for dwell service. For a rotation of ± 15 deg from the horizontal, maximum variation of X is 0.0013 in. for a stroke of 5.3 in.

used to advantage in the development of certain types of cams as well as cam generators. However, in its function as a displacement-generating mechanism, the cycloid can only reciprocate or continue in one direction to infinity. This characteristic limits its practical usefulness as a machine element.

Epicycloidal and Hypocycloidal Systems: If the generating circle is rolled along either the outside or inside of another fixed circle, an epicycloidal or hypocycloidal displacement curve is generated. Both of these curve forms can be readily adapted to machine applications.

A typical epicycloidal crank is depicted schematically in Fig. 2. The planet gear in mesh with the fixed sun gear is journaled into a lever which is driven at constant velocity by the drive shaft. The other end of the planet-gear shaft is keyed to an eccentric crank which engages a slotted output lever through a sliding block. Crank action drives the output lever at a variable velocity which is dependent on the effective crank length, d, as compared with the pitch radius, r, of the planet gear. If $d = 0$, velocity of the output lever is constant. If $d = r$, a momentary dwell will occur when the crank pin is in line with the pitch point common to the two gears. If $d > r$, a slight reversal of motion will be obtained.

The physical arrangement of the hypocycloidal crank is basically the same as for the epicycloidal system except that a fixed internal gear is employed instead of an external gear.

An analysis of the displacement curves for the epicycloidal and hypocycloidal* mechanisms shows that their motion characteristics are fundamentally the same as those of the cycloid. In addition, they can be used for rotary motion and with varying combinations of gear ratio and crank length.

Acceleration characteristics of motions generated by different mechanisms are compared in Fig. 3. As the gear ratio for the epicycloidal crank increases, the acceleration curve approaches the cycloidal form. This condition is natural since in the cycloidal system the gear ratio equals infinity.

For an epicycloidal crank with 1:1 gear ratio, the acceleration peaks quickly near the beginning of displacement and then diminishes rapidly. Thus, during the period of maximum velocity, acceleration is a minimum. The effect of gear ratio and how it shifts the point of peak acceleration is clearly shown by the curves, Fig. 3.

Analysis of forces developed in cycloidal cranks shows that, during periods of maximum acceleration, the moment about the crank shaft is relatively small in comparison to the planet-gear radius. Thus, the gear teeth are not subjected to high loading.

Rotary-Motion Applications: A wide range of motion characteristics can be obtained with epicycloidal and hypocycloidal-crank combinations. Some of the more important variations are high-

*E. H. Schmidt—"Cyclic Variation in Speed," MACHINE DESIGN, Vol. 19, No. 3, March, 1947, pp. 108-111 and 182.

lighted in the following discussion.

A hypocycloidal crank with 2:1 gear ratio offers a simple mechanism for generating a true ellipse. The eccentricity of an ellipse can be said to vary between a circle and a straight line which is twice the length of the circle diameter. In the 2:1 hypocycloidal crank, Fig. 4, as crank length d varies from 0 to r, the locus of the path varies from a circle to a straight line. Any value of d between these limits will describe an ellipse with intercepts of $r + d$ and r-d.

For a 2:1 epicycloidal crank, Fig. 5, crank length d can be determined so that for a 30-deg rotation of the sun gear or input shaft the horizontal position (X co-ordinate) remains practically constant. If the crank is coupled to a reciprocating crosshead, similar to a scotch yoke, a 30-deg dwell at each end of the stroke can be obtained.

A similar motion, not quite as accurate as the previous one but having a greater dwell time, is the square pattern generated by a 4:1 hypocycloidal crank, Fig. 6.

Another combination, Fig. 7, consists of a 3:1 hypocycloid with the crank located on the pitch radius of the planet gear. Locus of the crank path is almost a perfect arc. If the crank is connected to a rod equal in length to the arc radius, a crosshead can be reciprocated through a given stroke with an approximate dwell of 1/3 of the cycle at one end of the stroke. For a 4-in. stroke, maximum deviation during the dwell is 0.222 in.

If an epicycloidal crank is designed with planet-gear radius equal to twice that of the sun gear, two revolutions of the driving arm are required to produce a full revolution of the planet gear about its own axis. In such an arrangement, two alternate displacements of varying length can be obtained by properly locating a crank on the planet gear, Fig. 8*a*. The path shown is for only one revolution of the crank. The second revolution of the crank will produce a symmetrical path about the vertical axis. If the crank is used to drive a crosshead with a horizontal slot or the crank pin is connected to a crosshead by a connecting rod, alternate long and short strokes will be produced. In Fig. 8*a*, upper position for both strokes would be common while the lower portion would alternate between points A and B. An actual application of this system in a transfer mechanism is shown in Fig. 8*b*.

Indexing Applications: The simplest application of the cycloidal mechanism for indexing consists of driving the input to the crank element by a single-revolution clutch. If a 1:1 epicycloidal crank is used, the clutch can be synchronized to disconnect the driving arm from the constant-speed drive shaft when the crank is at the zero velocity point. At this time, the driven member will be at rest and the only energy absorbed by the clutch will be the kinetic energy of the rotating arm, planet gear, and crank. This arrangement permits a fair amount of variation of the point at which the clutch disengages without affecting the location of the indexed system.

For a more positive drive with better timing, in-

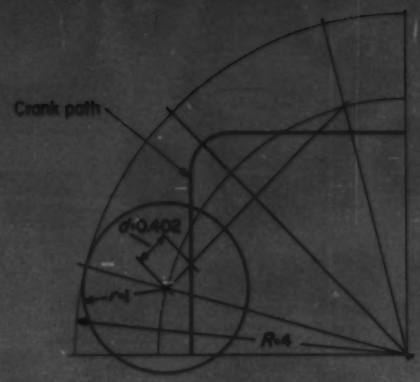


Fig. 6—Hypocycloidal crank with 4:1 gear ratio for generating square motion path

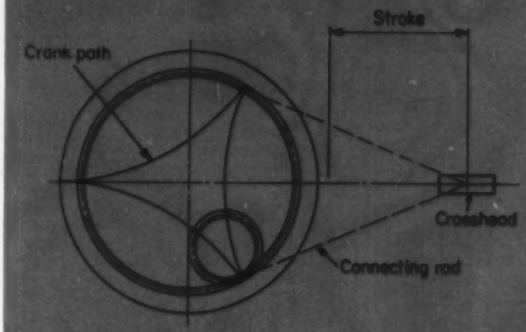
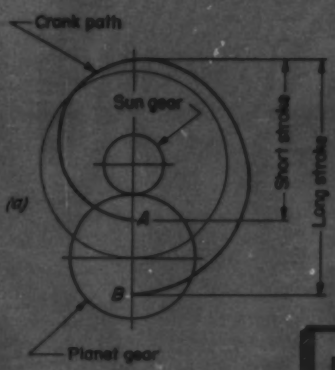


Fig. 7—Hypocycloidal crank with 3:1 gear ratio for dwell service. Crank is located on the pitch radius of the planet gear and is connected to the cross head by a rod equal in length to the radius of the crank path arc. An approximate dwell of 1/3 of the operating cycle is obtained at the right-hand end of the stroke



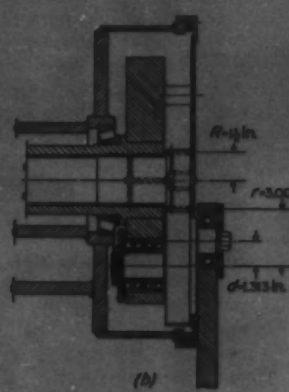
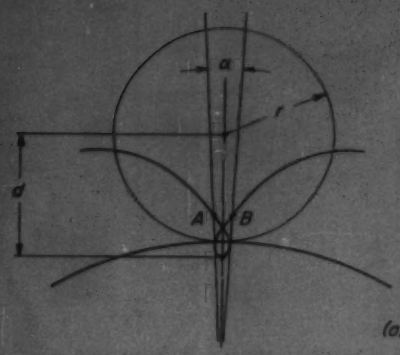


Fig. 8 — Epicycloidal crank with 2:1 gear ratio for generation of alternate long and short strokes. Basic system, *a*, is employed in the transfer mechanism design at *b*



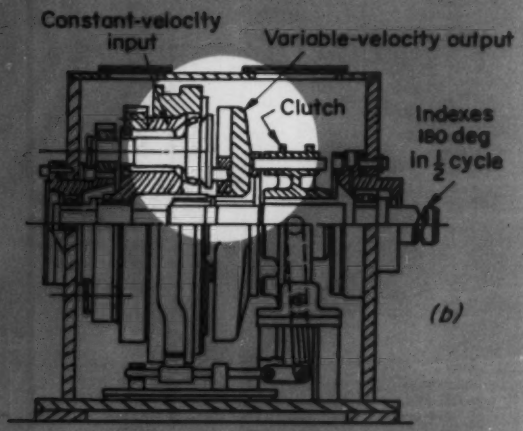


Fig. 9—Epicycloidal crank design for modified dwell characteristics. When crank length slightly exceeds the planet-gear pitch radius, null point in the motion path is changed from a sharp point to a small loop, *a*. This principle is employed in the 2:1 epicycloidal-crank indexing mechanism at *b* to increase dwell time provided for actuating a positive-clutch unit

termittent-motion gears can be driven with a cycloidal crank to avoid the high impact shocks normally present during engagement and disengagement of the gears.

In the development of an indexing mechanism capable of high-speed operation and accurate positioning, some positive-clutching device should be provided to connect and disconnect the driven system and to lock it in position during the dwell. When $d = r$ in an epicycloidal crank, theoretical dwell time is zero, which does not provide much allowance for actuating a positive-clutch arrangement.

As a possible solution to this problem, effect of slightly increasing the crank length was investigated, Fig. 9*a*. This modification changes the null point of the "cusp" of the motion path from a sharp point to a small loop, depending upon the extent to which the crank length is increased. Based on this investigation, the conclusion was reached that, in general, when the crank length is extended 0.008 in. per in. beyond the planet-gear pitch radius, angular output will vary only 2 min 37 sec for a 16-deg displacement of the input. This change represents a variation of 0.0007 in. per in. in the radius of the output lever. This slight angular variation was not considered detrimental. Thus, the modified system provides a 16-deg movement of the input shaft for actuation of a positive-clutch unit. A patented application of this principle, using a 2:1 epicycloidal crank is shown in Fig. 9*b*.

The largest cycloidal-crank indexing mechanism built to date indexes 5000 lb through 4 ft in 2 sec, which represents ¼ cycle. It then dwells for ¾ of a cycle. A 2:3 epicycloidal crank is used so that the angular position of the cusps is 240 deg.

ACKNOWLEDGMENT

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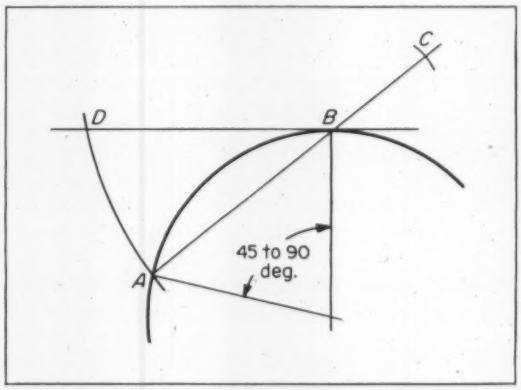
Tips and Techniques

Arc Length

A straight line equal in length to a circular arc *AB* (between 45 and 90 degrees) can be laid off quickly by this method. Draw a tangent at *B* and the chord *BA*. Lay off *BC* equal to the chord of half



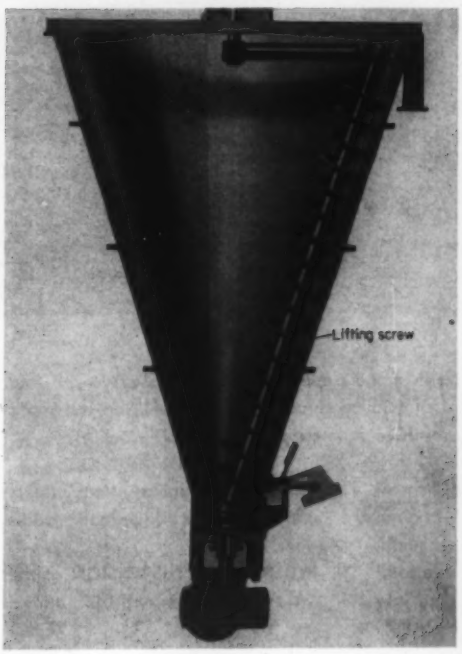
the arc. With center *C* and radius *CA*, draw an arc which intersects *BD* at *D*. Hence, *BD* will be equal in length to the arc *AB*.—ROLF B. ERICSON, *Trollhattan, Sweden.*

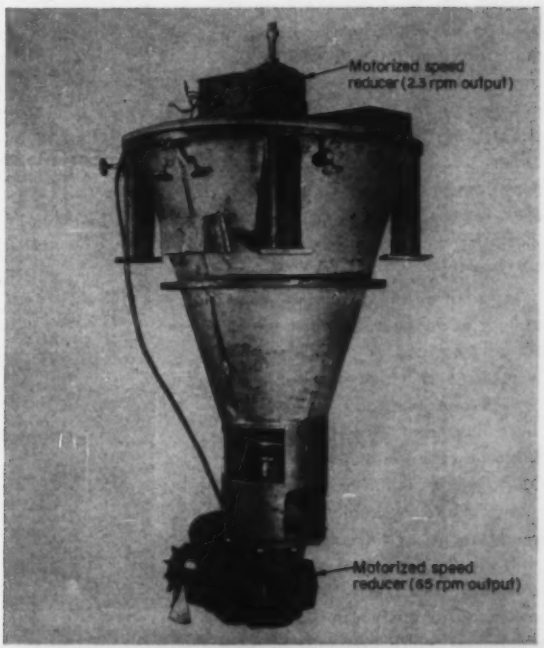
Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor. MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

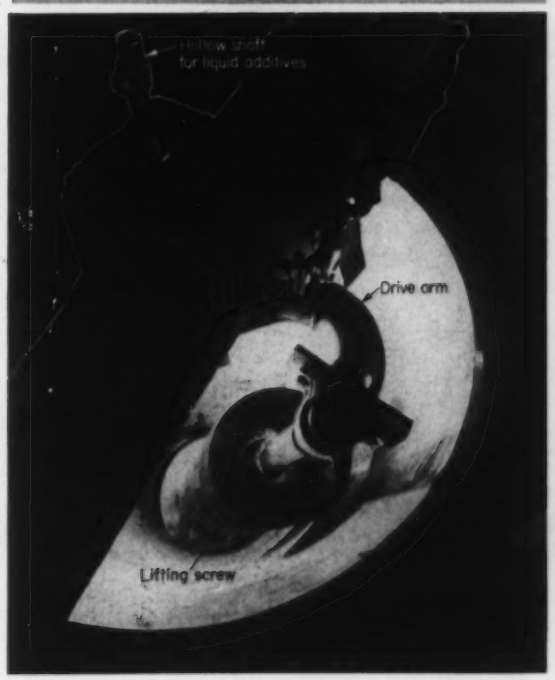
Rotating Mixing Screw Is Revolved in Conical Pattern

PRECESSIONAL MOTION of a rotating screw traveling around the interior of a conical body thoroughly mixes dry or wet materials. Applied in Nauta mixers designed by Buflovak Equipment Div., Blaw-Knox Co., Buffalo, N. Y., the screw mixes materials in any proportion without dusting.

In operation, the screw member lifts material to the top while it travels around the inside surface of the conical container.



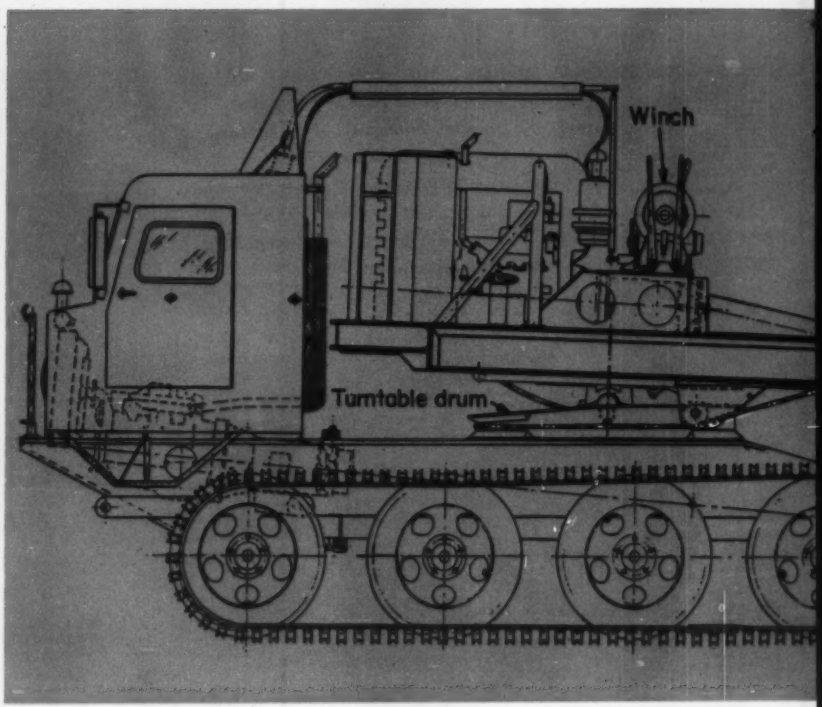




SLOW-SPEED DRIVE POWER for rotating the screw flight around the conical body is produced by a motorized wormgear speed reducer manufactured by Cone-Drive Gears Div., Michigan Tool Co., Detroit. Speed reduction of the unit is 500 to 1, giving an output speed of 2.3 rpm. A hollow shaft in this reducer permits adding liquids or inserting measuring instruments into the mixer.

A shaft-mounted gearmotor at the bottom of the mixer turns the lifting screw itself at 65 rpm. This gearmotor has a 270 to 1 reduction.

Powered Cables from Trailer



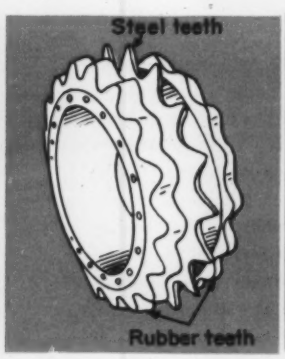
"POWER STEERING" of a four-tracked vehicle is accomplished by pivoting the whole tractor either to the left or the right with steel cables connected to two hydraulic cylinders mounted on the trailer. This method of steering eliminates individual brakes or separately controlled drive power to each track. However, there are brakes on the driveshafts from each engine for downhill braking.

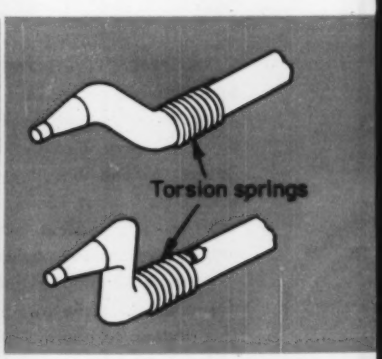
Mounted on the deckframe of the trailer, each hydraulic cylinder is 60 in. long and 4 in. in diameter. Two pieces of heavy steel cable are wrapped around and anchored to the center front of a 4-ft diameter turntable drum on the tractor. Cable ends are attached to the piston rods. High-pressure hydraulic fluid, applied to one of the two cylinders, pulls the cable into that cylinder and turns the tractor in relation to the trailer. A remotely operated valve determines which hydraulic cylinder is powered and, in turn, vehicle direction.

Designed and manufactured by Bruce Nodwell Ltd., Calgary, Alberta, Canada, the tractor-trailer unit is 39½ ft long and has a top speed of 12 mph. The vehicle is powered by two Ford 292 cu in., eight-cylinder, OHV engines—one in the tractor and one on the front of the trailer. These engines power all four tracks and provide a total of 236 hp through six-speed Allison automatic transmissions and planetary-drive rear axles.

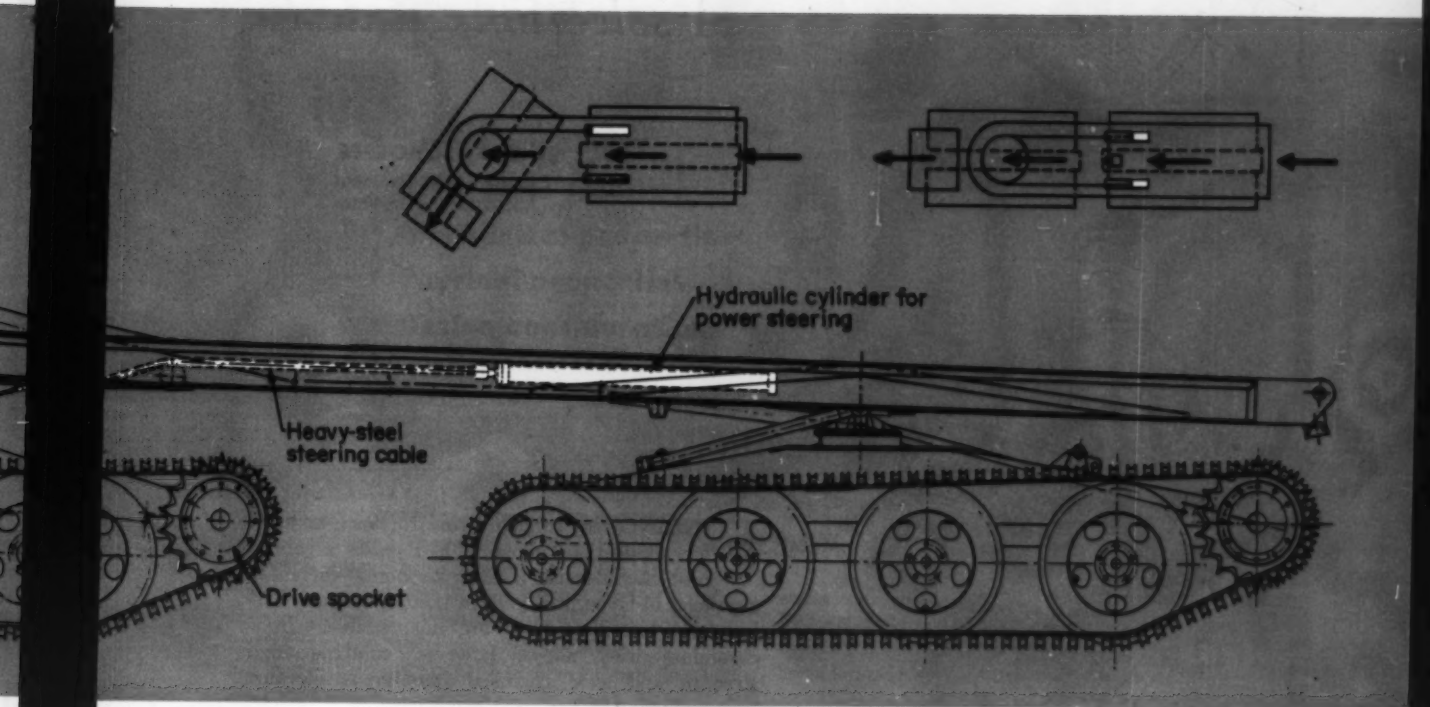
RUBBER-TOOTHED SPROCKET member drives each track. Although each sprocket has 36 rubber teeth, a center row of steel overload teeth are added which come into contact with metal track cleats under extreme drive-load conditions.

INDEPENDENT SUSPENSION of the 16 rubber-tired wheels allows



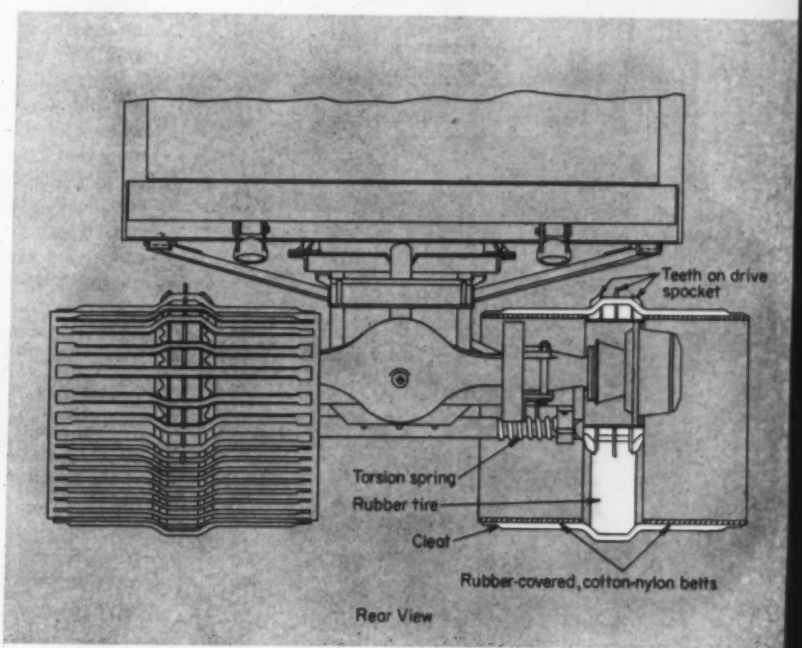


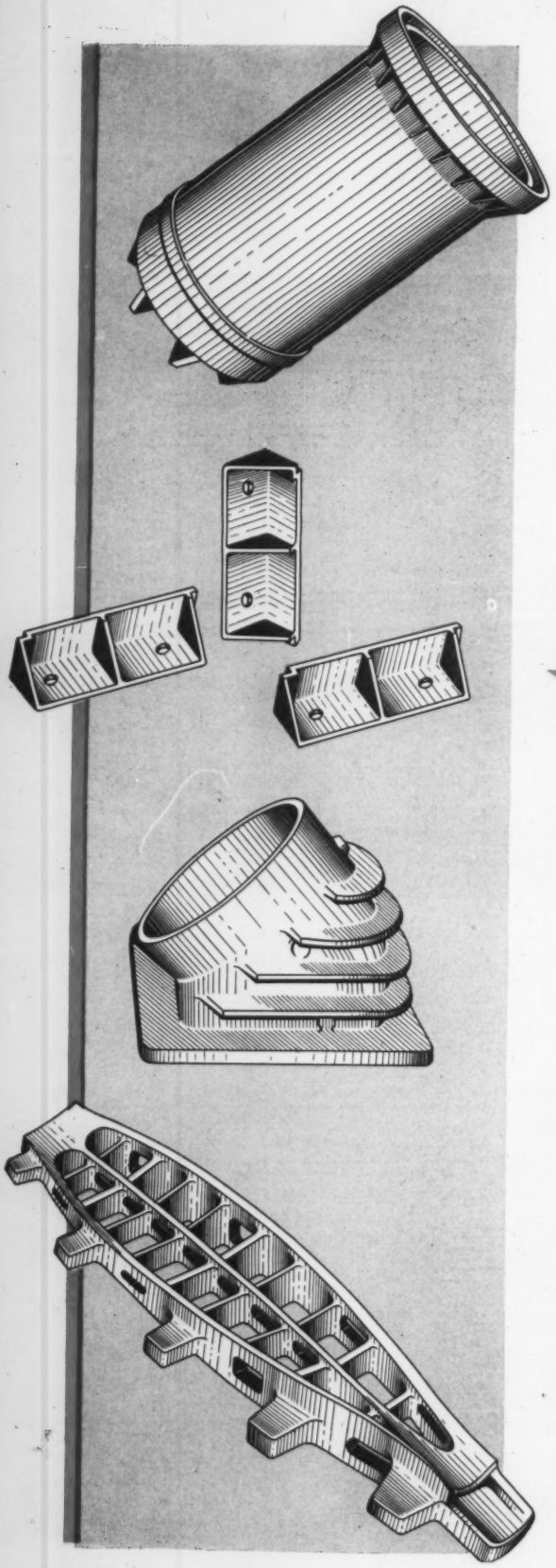
Pivot Whole Tractor



equal distribution of the load over uneven terrain. Each wheel is mounted on a split Linco Level-load axle. Each axle shaft is fastened to a torsion spring which is, in turn, anchored to the vehicle chassis.

LOW GROUND PRESSURE is developed by the tracks, which are 48 in. wide. A fully loaded vehicle (53,000 lb) produces a ground pressure of only 1.89 psi, making it ideal for travel over soft terrain. Each track is composed of two 18-in. wide strips of rubber-covered, cotton-nylon belts which are attached to silicon-manganese steel cleats.





A selection guide to

By E. A. SCHOEFER
Executive Vice President
Alloy Casting Institute
Mineola, N. Y.

FINDING a suitable construction material for applications above 1200 F poses a serious problem. Because most atmospheres—including air—tend to be corrosive above 1200 F, ordinary carbon and low-alloy steels are not reliable. Iron-chromium-nickel alloys, however, combine high strength and good chemical stability at elevated temperatures and are used extensively in structural components for service at 1200 to 2200 F. At these temperatures, ordinary carbon and low-alloy steels are relatively weak and exhibit progressive scaling from the hot atmospheres.

Parts cast from the Fe-Cr-Ni alloys are especially suitable for high-temperature service for several reasons: 1. Grain structure is inherently more rigid than that of rolled products. 2. Since the chemical compositions of the cast high alloys are designed specifically for high-temperature use, these alloys can be made stronger than "corresponding" wrought alloys; the wrought alloys are compounded to permit relatively easy hot working but at the expense of high-temperature strength. Since many useful compositions cannot be rolled or forged successfully, fewer wrought materials are available than casting alloys.

Types of Casting Alloys: Two series of casting alloys are available: The corrosion-resistant ACI C series, similar to the wrought stainless types, and the heat-resistant H series characterized by a considerably higher carbon and nickel content.[1,2] The Alloy Casting Institute designations for cast heat-resistant alloys are shown in Table 1 with related wrought-alloy types where such exist. These desig-

[1]References are tabulated at end of article.

Heat-Resistant Cast High Alloys

- **Surface stability**
- **Structural stability**
- **Mechanical properties**
- **Physical properties**
- **Design considerations**

nations, not those for wrought forms, should be used when specifying castings.

Special alloys using cobalt or nickel as a base material are available for jet engines and other aircraft applications. Although more costly than the Fe-Cr-Ni alloys, they have extremely high strength between 1200 and 1600 F. Above 1600 F, they are comparable in strength, or inferior, to the Fe-Cr-Ni alloys.

Surface Stability

Ability to withstand corrosive attack from hot gases is essential for any exposed part intended for prolonged service at high temperatures. Cast heat-resistant alloys are not immune to attack, but the rate at which they corrode is sufficiently slow to make their use practical. Resistance to different atmospheres, however, may vary widely with alloy type. Thus, the expected rate of corrosion is a prime consideration at the start of a design, and all stress calculations should take this factor into account.

Influence of Nickel-Chromium Content: Atmospheres to which cast parts are exposed include air, fuel-combustion products, and prepared atmospheres for carburizing, carbonitriding, or other heat treatments. Heat-resistant alloys for service in such

Table 1—Composition of Heat-Resistant Cast High Alloys

ACI Alloy Designation	Corresponding Wrought Alloy	Major Elements (per cent) C	Mn (max)	Si (max)	P (max)	S (max)	Cr	Ni	Other Elements* (max)
HA	...	0.20 max	0.35 to 0.65	1.00	0.04	0.04	8 to 10	.....	Mo 0.90 to 1.20
HC	446	0.50 max	1.00	2.00	0.04	0.04	26 to 30	4 max	Mo 0.5
HD	327	0.50 max	1.50	2.00	0.04	0.04	26 to 30	4 to 7	Mo 0.5
HE	...	0.20 to 0.50	2.00	2.00	0.04	0.04	26 to 30	8 to 11	Mo 0.5
HF	302B	0.20 to 0.40	2.00	2.00	0.04	0.04	19 to 23	9 to 12	Mo 0.5
HH	309	0.20 to 0.50	2.00	2.00	0.04	0.04	24 to 28	11 to 14	Mo 0.5
									N 0.2
HI	...	0.20 to 0.50	2.00	2.00	0.04	0.04	26 to 30	14 to 18	Mo 0.5
HK	310	0.20 to 0.60	2.00	2.00	0.04	0.04	24 to 28	18 to 22	Mo 0.5
HL	...	0.20 to 0.60	2.00	2.00	0.04	0.04	28 to 32	18 to 22	Mo 0.5
HN	...	0.20 to 0.50	2.00	2.00	0.04	0.04	19 to 23	23 to 27	Mo 0.5
HT	330	0.35 to 0.75	2.00	2.50	0.04	0.04	13 to 17	33 to 37	Mo 0.5
HU	...	0.35 to 0.75	2.00	2.50	0.04	0.04	17 to 21	37 to 41	Mo 0.5
HW	...	0.35 to 0.75	2.00	2.50	0.04	0.04	10 to 14	58 to 62	Mo 0.5
HX	...	0.35 to 0.75	2.00	2.50	0.04	0.04	15 to 19	64 to 68	Mo 0.5

*Molybdenum not intentionally added except in Type HA.

atmospheres can be divided for convenience into three groups:

Group 1: Types HA, HC, and HD, the iron-chromium alloys containing from 8 to 30 per cent chromium and less than 7 per cent nickel.

Group 2: Types HE, HF, HH, HI, HK, and HL, the iron-chromium-nickel alloys containing from 19 to 32 per cent chromium and from 8 to 22 per cent nickel.

Group 3: Types HN, HT, HU, HW, and HX, the iron-nickel-chromium alloys containing from 23 to 68 per cent nickel and from 10 to 23 per cent chromium.

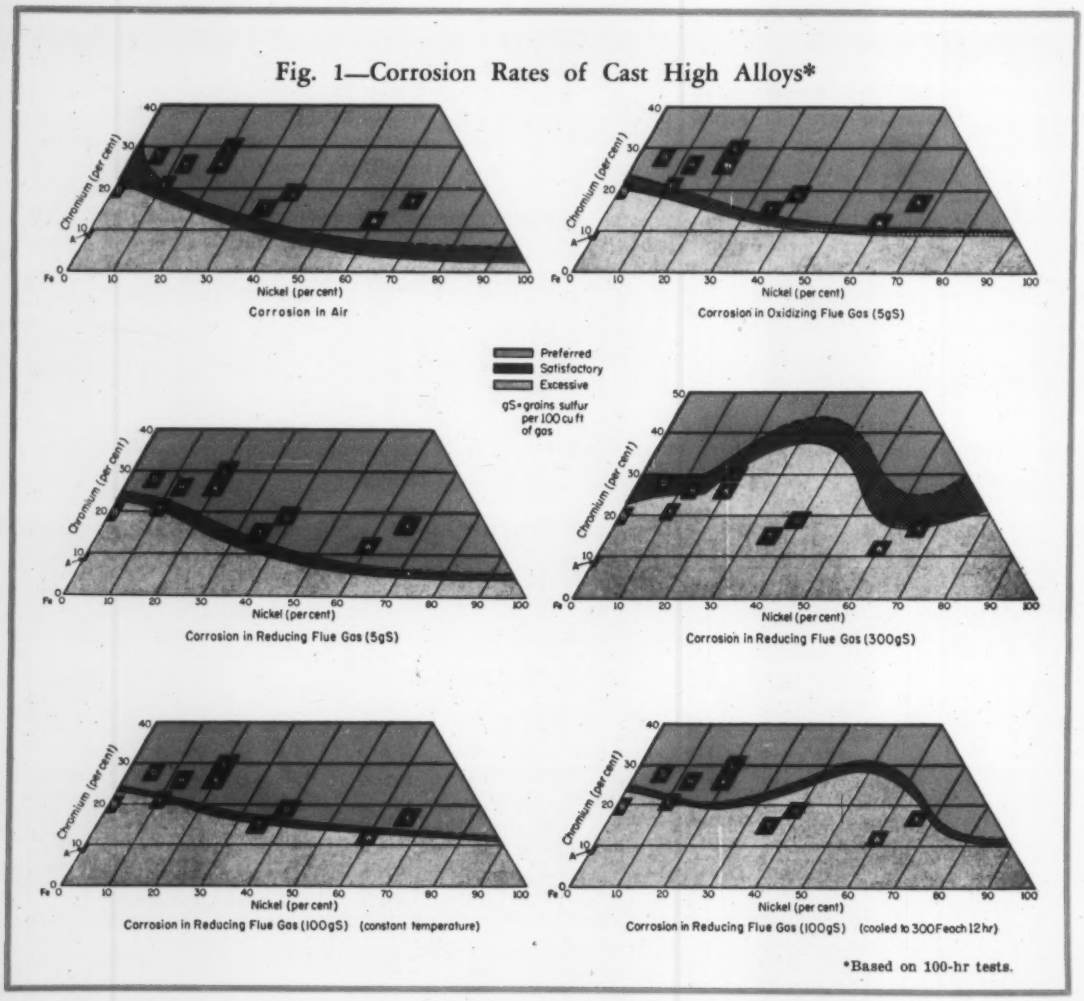
Surface stability of these 14 alloys generally improves as the total chromium and nickel contents are increased.

Since many atmospheres are oxidizing in effect, chromium is included in each grade for high-temperature oxidation resistance. Nickel, although not as effective as chromium, helps promote resistance to hot-gas corrosion. At higher nickel contents, less chromium is required for a given level of resistance. Nickel also imparts carburizing and nitriding resistance to the alloys, but alloys high in nickel content are attacked if atmospheres have high sulfur contents.

Rate of surface attack is largely determined by the type of scale that forms. A tightly adherent scale is protective, and alloys forming such scales exhibit decreasing corrosion rates. A scale that is friable and flakes off, however, continually exposes new metal to the atmosphere, and a constant, high rate of attack results. A specific constituent in the atmosphere, such as sulfur, may react with the scale to form a low-melting-point compound which, by fluxing action, causes a rapid removal of scale and accelerates rate of attack.

Rates of attack also depend on the temperature to which the alloy is exposed. At temperatures from 900 to 1200 F, all the alloys perform satisfactorily. As temperature increases, the number of serviceable alloys in each group is reduced and, for service at approximately 2000 F, only alloys with the highest combined nickel and chromium content remain for consideration. These include types HC and HD of Group 1, types HI and HL of Group 2, and types HU and HX of Group 3.

Fig. 1—Corrosion Rates of Cast High Alloys*


Chromium (per cent)
Nickel (per cent)
Fe
Corrosion in Air
Corrosion in Oxidizing Flue Gas (5gS)
Preferred
Satisfactory
Excessive
gS=grains sulfur per 100 cu ft of gas
Corrosion in Reducing Flue Gas (5gS)
Corrosion in Reducing Flue Gas (300gS)
Corrosion in Reducing Flue Gas (100gS) (constant temperature)
Corrosion in Reducing Flue Gas (100gS) (cooled to 300 F each 12 hr)

*Based on 100-hr tests.

Hot-Gas Corrosion: In flue gas, or atmospheres containing products of combustion, rates of attack for various grades are influenced by the oxidizing or reducing character of the gas.[3] An oxidizing atmosphere contains free oxygen but no carbon monoxide, and a reducing atmosphere contains carbon monoxide but no oxygen. Such atmospheres result from burning fuel with either an excess or deficiency of air.

To about 1800 F, alloys in Groups 1 and 2 behave about the same in oxidizing or reducing flue gas as in air.[4] At higher temperatures, corrosion rates in flue gas are slightly less than in air for most alloys of Groups 1 and 2, and there is little difference in rate of attack for gases with low and high sulfur content.

Alloys in Group 3 show satisfactory corrosion resistance below 1900 F in oxidizing flue gas containing less than 100 grains of sulfur per 100 cu ft, and in reducing flue gas containing 5 grains or less per 100 cu ft.* Reducing atmospheres with high sulfur contents are resisted only by alloys HX and HU in Group 3 at temperatures to 1800 F. Higher sulfur content (200 grains or more per 100 cu ft) is resisted satisfactorily only by Types HC and HD of Group 1 and Type HE of Group 2. Relative corrosion resistance of the Fe-Cr-Ni alloys in various atmospheres at 1800 F is shown in Fig. 1.[5]

Carburizing Resistance: Good life in carburizing service is a characteristic of the Group 3 alloys. A high nickel content promotes resistance to carburization, and the amount of carbon penetration that does occur is not reflected in a loss of ductility. Alloys in Groups 1 and 2 are less satisfactory than those in Group 3 because they show carbide embrittlement. When the choice of an alloy in Group 1 or 2 is dictated by some other consideration, carburization resistance of some of these alloys can be improved by increasing silicon content to about 1.5 per cent.

Heat-resistant castings are also used as containers for molten metals or salts. As such, the alloy is exposed to corrosion by liquid and gaseous media. Type HH in Group 2 and Type HT in Group 3 are most frequently used for liquid-metal containers. Similar to their use in gaseous carburizing service, Group 3 alloys are generally employed to hold carburizing salts. Selection of an alloy to resist these highly corrosive materials should not be attempted without expert guidance.

Structural Stability

At constant elevated temperatures, an alloy must have the ability to function without undergoing microstructural change through precipitation or solution of minor constituents. Certain alloys depend on precipitated compounds to achieve high strength. If these precipitates are redissolved at or near the operating temperature, mechanical strength of the metal is sharply reduced. Other alloys are embrittled by precipitates if held at certain temperatures. If these temperatures coincide with the operating temperature of the part, serviceability of the alloy may be destroyed.

If an alloy is to be exposed to thermal cycling, especially from room temperature to operating temperature, it is also essential that no major phase change occur. Cyclic changes, such as from ferrite to austenite and back, warp and distort the structure. Such a change in crystal structure permits development of a wide range of mechanical properties through heat treatment and grain refinement. This same change, however, also makes materials such as steel and low alloys unsuitable for prolonged cyclic heating where maximum operating temperature is above the transition range.

Commercial heat-resistant alloys of Groups 2 and 3 depend partly on their high carbon content to achieve high strength through the formation of chromium carbides. Since these do not dissolve completely until the temperature exceeds 2000 F, such alloys can be used for load-carrying service at temperatures as high as 2200 F.

Composition Balance of Fe-Cr-Ni Alloys: Group 1 alloys are ferritic at all temperatures up to the melting point and do not undergo major phase changes in cyclic service. Types HC and HD, however, do become embrittled if held for any appreciable length of time at temperatures from 1500 to 1600 F.

Group 2 alloys are basically austenitic in structure, but varying amounts of carbides may also be present depending on the composition balance and thermal history of the casting. In the as-cast condition, there are usually large, primary carbides scattered throughout the matrix. After aging at service temperature, the alloys may exhibit fine, dispersed carbides which contribute to creep strength.

All of the Group 2 alloys must have closely controlled composition balance to obtain desired structures. Type HE is always a two-phase austenite-ferrite alloy and will become embrittled from a weak, intermediate-phase structure formation (sigma phase) if exposed for long times at 1500 to 1600 F. Types HF and HH are borderline and may be made either wholly austenitic or partially ferritic within the normal chemical ranges. Types HI, HK, and HL are usually wholly austenitic as produced, but unbalanced HK and HL alloys may develop sigma phase at approximately 1600 F. Absorption of carbon from the atmosphere may result in serious embrittlement of Group 2 alloys especially if castings are held near 1200 F. For this reason, alloys in Group 3 are generally used for carburizing service particularly when thermal cycling.

Group 3 alloys are wholly austenitic at all temperatures and are not as sensitive to composition balance as alloys in Group 2. They also contain large, primary chromium carbides in the austenitic matrix and, after exposure to service temperature, show fine, precipitated carbides. Such precipitates decrease room-temperature ductility of the alloys but have little effect on ductility at high

*Combustion gases of high-grade fuel oil containing 0.7 per cent by weight of sulfur, for example, would have 60 grains of sulfur per 100 cu ft.

temperatures. This characteristic makes the alloys useful for carburizing fixtures or containers.

The HW and HX types have the greatest tolerance for absorption of carbon from the atmosphere without deleterious effects on ductility. For this reason, these alloys are used where carburization is combined with severe thermal shock, such as in quenching fixtures.

Mechanical Properties

Reported elevated-temperature data showing comparative strengths of the various alloy types contain a time factor that is absent in conventional room-temperature test results. Because high-temperature structures operate in the region of plastic, not elastic, strain, the designer must not overlook this time factor when choosing a suitable design stress. Accordingly, required life of the part is an important consideration in alloy selection.

Room-temperature tension-test results are not satisfactory criteria for selecting a high-temperature alloy. Such tests, made after an alloy has been exposed to service temperatures, are indicative of the change in properties that may be expected after a casting has been in service. This may be of some importance if castings are to be subjected to mechanical handling at room temperature.

Factors Influencing Design Stress: Selection of design stress must be based on elevated-temperature tests. Among these are the short-time elevated-temperature tests, stress-rupture tests, and creep tests. Short-time elevated temperature tests are useful only in indicating maximum load that can be sustained for a corresponing short period of time. Stress-rupture values or creep-test results must be used for extended service.

For extended service, designers must consider rate of deformation of a loaded part at constant temperature, or the life that can be obtained before fracture at some particular stress level. To make allowance for plastic flow exhibited by metals at elevated temperatures, and to provide information on deformation, values are reported at different temperatures for a limiting creep stress. These values are frequently given for a stress that will produce a creep rate of 0.0001 per cent per hr or, as sometimes stated, 1 per cent in 10,000 hr. Where fracture time is the criterion, stress-to-rupture values are reported for 10, 100, and 1000 hr or more.

A frequently suggested design stress is 50 per cent of the stress that will produce a creep rate of 0.0001 per cent per hr at maximum operating temperature. Such a value should be applied only under conditions of direct axial static loading and essentially uniform temperature or slowly varying temperature. Where impact loading or rapid temperature cycles are involved, a much lower percentage of the limiting creep stress should be used.

In the selection of design stresses, safety factors should be high if parts are inaccessible, nonuniformly loaded, or of complex design. They may be low if parts are accessible for replacement, fully supported or rotating, and of simple design with little or no thermal gradient. The greatest danger lies in extrapolation above the top temperatures for which data are available, since the mechanisms that shorten service life become more numerous and more potent as temperatures rise. Room-temperature and high-temperature properties of the Fe-Cr-Ni alloys are shown in Fig. 2.

Where strength is not a consideration, or where loading is moderate at temperatures near 1200 F, alloys in Group 1 can be used if other factors are favorable. Since increased nickel content gives higher hot strength through formation of the austenitic phase, alloys in Groups 2 and 3 are better suited for more highly stressed applications than alloys in Group 1.

At room temperatures, the spread in strength properties is relatively small. In general, the nickel-predominating alloys show somewhat lower values than the chromium-predominating alloys. As shown in Fig. 2*a*, many of the heat-resistant types have ultimate tensile strengths near 75,000 to 85,000 psi and yield strengths of about 50,000 psi at room temperature. On the other hand, there is a wide spread in values for short-time elevated-temperature tensile tests, Fig. 2*b*. At 1400 F, for example, Type HL has a strength of 50,000 psi in contrast to approximately 35,000 psi for the HH Type 1 alloy and 10,000 psi for Type HC. Thus, for parts with very brief life requirements such test values permit some choice among available alloys.

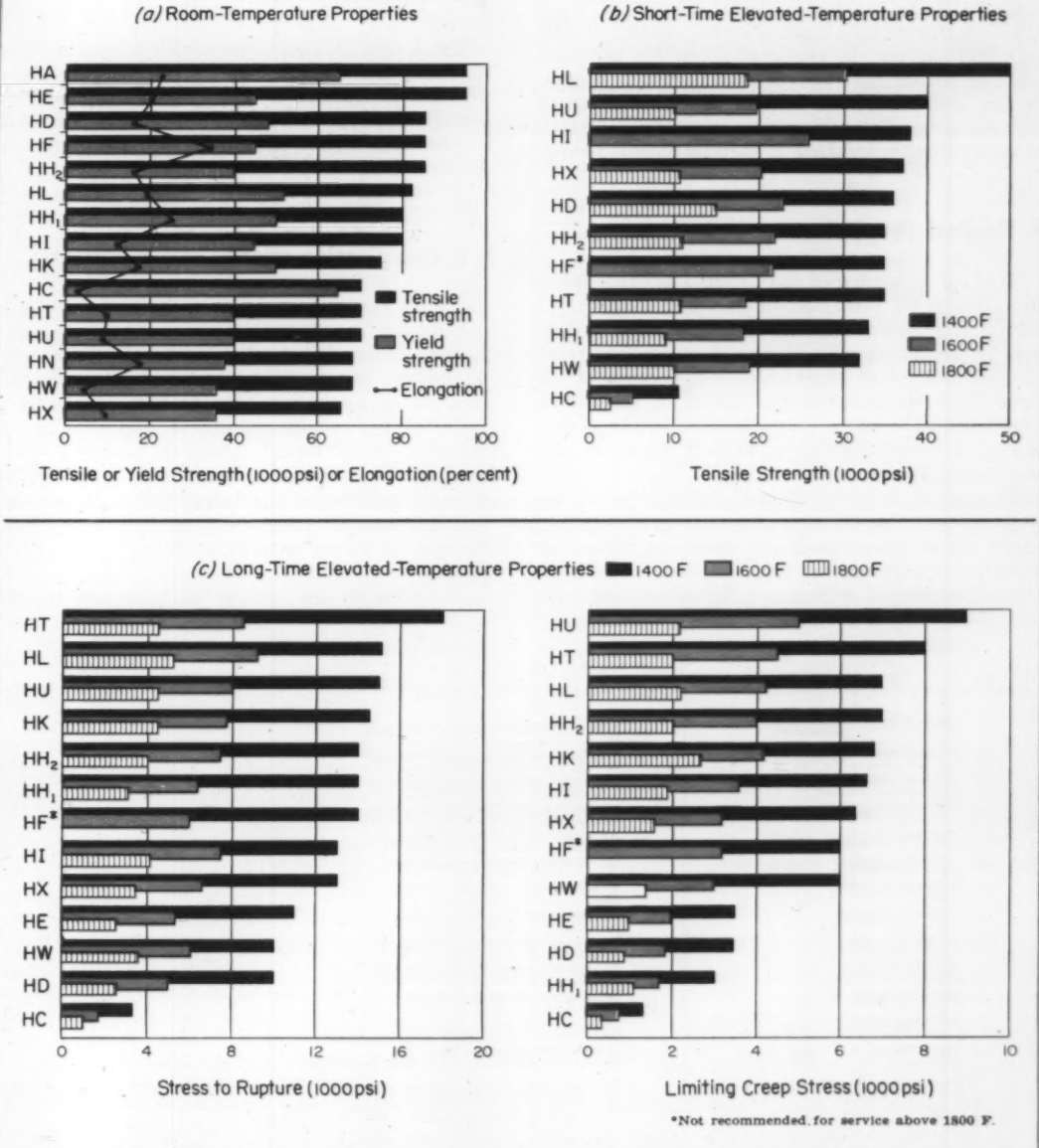
As aids in selecting suitable alloys and design stresses for parts requiring long life in usual elevated-temperature service, stress-to-rupture or creep values are much more significant, Fig. 2*c*. For example, contrast the high, 1600-F short-time strength of 30,000 psi for alloy HL with the much lower value of 18,800 psi for alloy HT, Fig. 2*b*. Note, then, how small the spread becomes for the 100-hr rupture strength (9200 vs 8500 psi), Fig. 2*c*. Finally, observe that the creep strength of the HT alloy is slightly higher than that of the HL alloy. Thus, the time element alone could be a deciding factor in correct alloy selection.

Thermal-Fatigue Failure: An important complication is introduced into high-temperature design when temperatures are cycling rather than steady. Thermal cycling usually increases creep rates. In the HT, HH, HK, and HU alloys, the effect of thermal cycling on creep rate is considerable at 1800 F or higher. At 1600 F, weakening is somewhat reduced, and at 1400 F the effect is negligible. Further complications of thermal cycling may occur where combined thermal and mechanical stresses cause plastic deformation and residual stresses of unknown magnitude. Thus, values shown in Fig. 2*c* must be modified downward for cyclic-temperature service. Values of Type HN alloy have been omitted since adequate field data are not yet available. However, this particular alloy appears to have very high strength at high temperatures.

High-temperature applications frequently involve conditions of thermal fatigue. This is a situation of repeated rapid heating and cooling such as encountered in heat-treating fixtures that are heated and quenched together with the material being processed. Comparative resistance to thermal-fatigue failure cannot be stated quantitatively because of the complex interrelation of strength and ductility characteristics of the alloys at the low and high extremes of the thermal cycle.

Thermal-fatigue failures are associated with stresses that result from thermal gradients. The steeper the gradient, the greater the stresses imposed. Accordingly, alloys having good hot ductility over a wide temperature range, and also displaying good retained ductility at room temperature, will be able to sustain a substantial number of thermal cycles. The higher ductility alloys, however, distort somewhat more than the lower ductility types but tend to give longer life. In thermal-fatigue applications, Group 3 alloys are generally used. The very high nickel contents of Types HX and HW are respon-

Fig. 2—Strength Properties of Cast High Alloys



*Not recommended for service above 1800 F.

sible for particularly good service under drastic cycling conditions.

The roles of various constituents should be understood in relation to their effect on hot strength of the alloys. Chromium, although of great influence in providing oxidation resistance, exerts only a minor beneficial effect on hot strength. Nickel, however, is essential for high hot strength because of its austenite-stabilizing effect. Carbon also promotes austenite stability and contributes greatly to hot strength of the alloys through formation of chromium carbides. The high carbon content of the cast high alloys constitutes the chief difference between these materials and the wrought stainless steels. It is the main reason for the generally superior hot strength of the cast heat-resistant alloys.

Silicon promotes resistance to oxidation and carburization but, in excess of about 1.8 per cent, tends to reduce hot strength and ductility. Molybdenum and columbium have a beneficial effect on hot strength. Columbium also improves resistance of some alloys to cracking in thermal-fatigue service.

Physical Properties

Thermal expansion of the Group 1 alloys is about the same as for plain carbon steel but, for Group 2 alloys, it ranges about 40 to 50 per cent higher, Fig. 3. Designers must always allow for free, overall extension of structural elements because of the large thermal-expansion coefficients of the alloys. Insufficient allowance for expansion within a part can be a major contributor to part distortion and short alloy life.

Because of the poor thermal conductivity of the high alloys, Fig. 3, steep thermal gradients can easily occur where parts are unevenly heated or cooled. As a result, the high expansion coefficient creates substantial differential expansion, and high stresses are imposed by one section of the part upon the remainder. Distortion produced by these thermal stresses is a major cause of thermal fatigue. Precautions should be taken, therefore, to avoid such stresses when thermal gradients are inherent in the design. It may be desirable, for example, to subdivide the component into several elements to obtain more uniform temperature distribution. Other physical properties of the cast high alloys are shown in Table 2.

Like the straight-chromium corrosion-resistant alloys, the straight-chromium heat-resistant types are ferromagnetic at room temperature. Alloys in Group 2 vary from nonmagnetic to weakly magnetic. Magnetism in Group 3 alloys depends on composition balance. Types HT, HU and HW are magnetic, while Types HN and HX are only slightly magnetic.

The Group 3 alloys have high electrical resistance and are characterized by low temperature-coefficients of resistivity. From room temperature to 1800 F there is an increase in resistance of only about 10 per cent. Thus, the alloys are useful for cast electrical heating elements.

Design Considerations

In most heat-resistant alloy types, sections 3/16 in. and thicker can be cast satisfactorily. Somewhat thinner sections are also feasible but depend on casting design, pattern equipment, and alloy composition. Thin sections cannot be cast as readily in the straight-chromium Group 1 alloys as in the chromium-nickel types. Alloys in Groups 2 and 3 have good castability and are satisfactory for designs having thin sections and intricate shapes. For any heat-resistant cast alloy, designs with drastic changes in section should be avoided and uniform thickness maintained whenever possible. This rule applies to the casting as cast, and includes

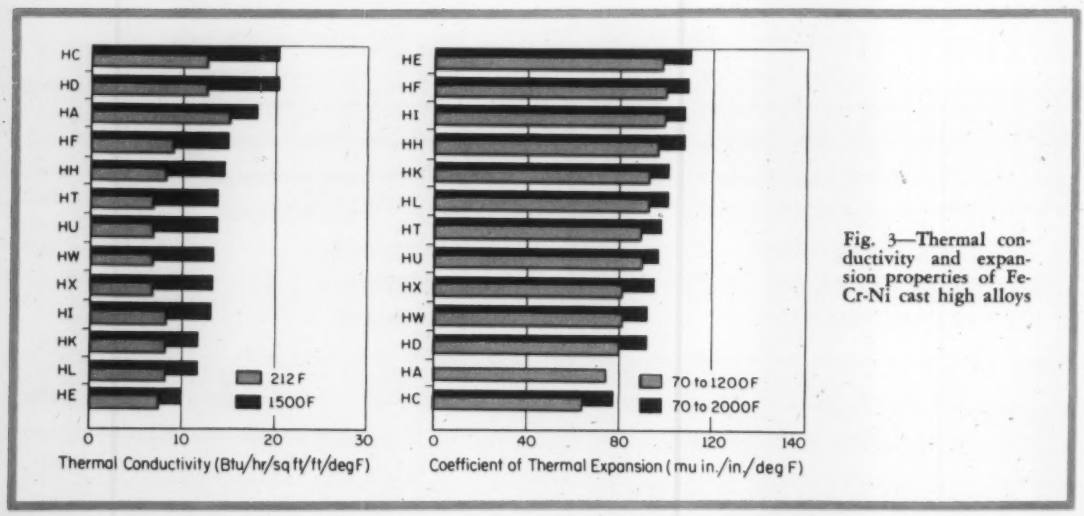


Fig. 3—Thermal conductivity and expansion properties of Fe-Cr-Ni cast high alloys

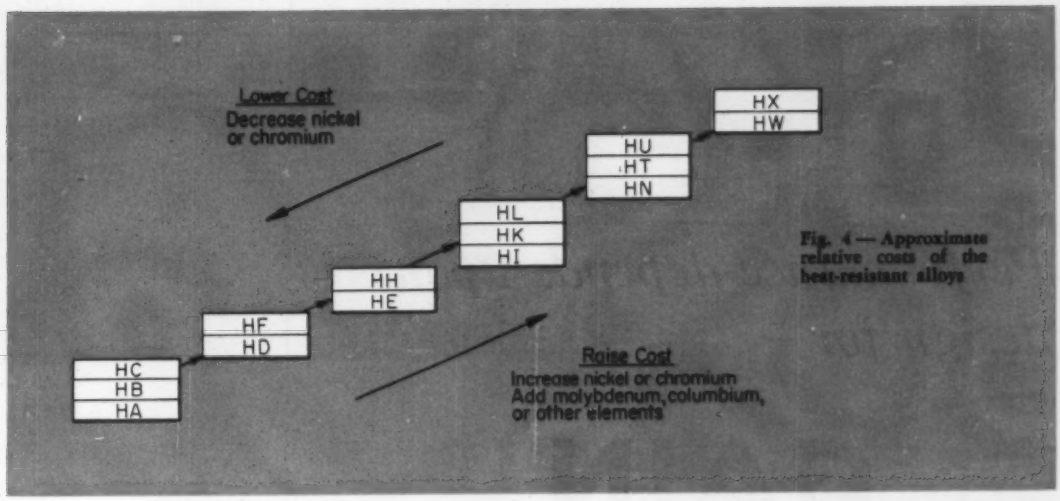


Fig. 4 — Approximate relative costs of the heat-resistant alloys

Table 2—Physical Properties of Fe-Cr-Ni Alloys

Alloy Type	Density (lb/cu in.)	Tensile Modulus (1,000,000 psi)	Specific Heat at 70 F (Btu/lb/deg F)	Magnetic Permeability μ	Electrical Resistivity (microhms/cu cm)
HA	0.279	29	0.11	Ferromagnetic	70.0
HC	0.272	29	0.12	Ferromagnetic	77.0
HD	0.274	27	0.12	Ferromagnetic	81.0
HE	0.277	25	0.14	1.3 to 2.5	85.0
HF	0.280	28	0.12	1.00	80.0
HH	0.279	27	0.12	1.0 to 1.9	75 to 85
HI	0.279	27	0.12	1.0 to 1.7	....
HK	0.280	29	0.12	1.02	90.0
HL	0.279	29	0.12	1.01	94.0
HN	0.283	27	0.11	1.10	....
HT	0.286	27	0.11	1.10 to 2.00	100.0
HU	0.290	27	0.11	1.10 to 2.00	105.0
HW	0.294	25	0.11	16	112.0
HX	0.294	25	0.11	2.0	....
Steel	0.283	30	0.12	Ferromagnetic	16

a finish allowance of at least $\frac{1}{8}$ in. on surfaces to be machined.

Designers should always indicate which surfaces of the casting are to be machined. This information will ensure a casting free from surface defects for the most satisfactory machinability. In general, overall dimensions and location of cored holes can be held to 1/16 in. per ft in sand castings. Best results are usually obtained when patterns are made or procured by the foundry producing the casting.

Alloy Fabrication: Most machining operations can be performed satisfactorily on the heat-resistant cast alloys.[5] The work-hardening effect encountered in machining is less pronounced in the alloys of Group 1 than in those of Groups 2 and 3.

Considerations of weldability are not limiting factors in selecting heat-resistant alloys.[6] Most types can be welded by metal-arc, inert-gas arc, and oxyacetylene techniques. For high-temperature applications, oxyacetylene methods are generally preferred for Group 3 alloys. Alloys in Groups 1 and 2 are generally welded by metal-arc methods. Preweld or postweld heat treatment is required for alloys in Group 1 but not for alloys in Groups 2 and 3.

Economics: Initial cost and cost per hour of service life are important considerations in selecting an alloy. It is obvious that a tray going into and out of a furnace, for example, can be replaced with little or no loss of furnace operating time whereas to replace a beam that is an integral part of the furnace might result in a loss of production for several days.

After eliminating materials on the basis of corrosion resistance, strength, physical properties, castability, and fabrication requirements, the designer may still have several alloys suitable for the job. Relative initial costs of the various alloys are shown in Fig. 4 and may be helpful in making the final selection. The chart cannot be considered as a guide to ultimate economy, however, since a more expensive alloy frequently provides lower operating cost then a less expensive type.

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Performance depends upon design for

GAIN
In Hydraulic-Control

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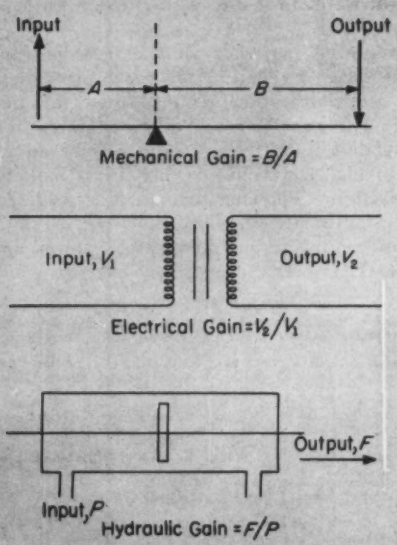
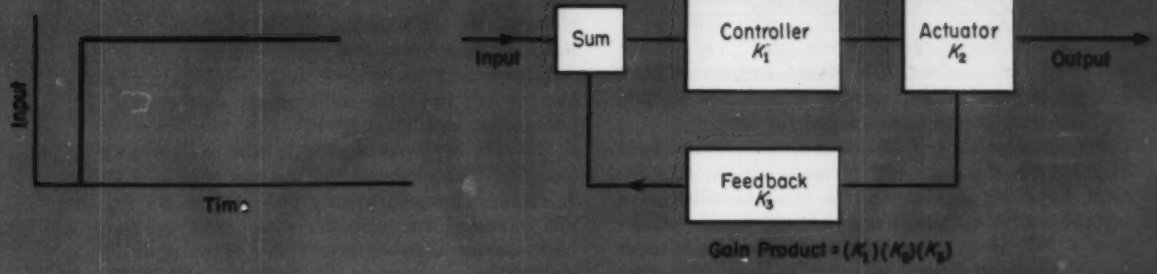


What is Gain?

The gain concept is the same for mechanical, electrical, and hydraulic systems. For the simple lever, the gain is the lever ratio, B/A, in units of inches output for a certain number of inches input. Similarly, the transformer has a gain of V_2/V_1, and the hydraulic cylinder has a gain of F/P pounds per psi. Gains need not be expressed in terms of like units.

Other terms, such as *proportional band* and *sensitivity*, are often used synonymously for gain. Sensitivity expresses the way in which the output responds to changes in input and builds a physical picture of the effect of gain. In some devices, such as a dial indicator, a large amount of gain or sensitivity is needed for operation. Conversely, a micrometer requires a very low gain for accurate measurement.



Systems

Here's how to adjust output/input ratio for optimum system response

EACH control element in a hydraulic system has a gain characteristic of its own, and the over-all response of the system is the product of the gains of all elements. Hence, it is often necessary to adjust the gain of the various elements to obtain an ideal system performance. This article describes some of the ways in which gain adjustment in hydraulic systems can be achieved.

Since gain affects the stability of the system, the larger the gain product, the more the control system tends toward instability. Fig. 1 shows responses obtained for systems with varying values of the gain product. If the gain product is too high, the system oscillates continuously.

In most control systems, it is important to have some means of adjusting the gain product. The ideal response depends upon the application, since some systems are set to operate slowly while others operate quickly. In either case, it is usually mandatory to have some means of making an adjustment to optimize the response.

While the adjustment of gain is a necessary function, other factors determine how this adjustment is achieved. Since it is often difficult to adjust some components, gain adjustment is limited to devices such as amplifiers, lever ratios, and adjustable-speed drives.

The point at which the gain can be adjusted is

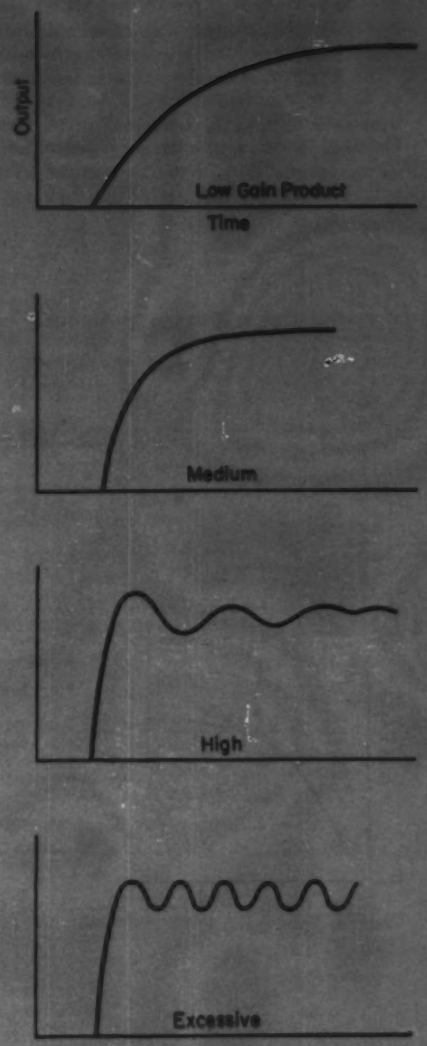


Fig. 1—Automatic-control system response for various gain products, (K_1) (K_2) (K_3)

another restriction often encountered. To achieve a desired gain product, it is often necessary to have a large amount of gain in one part of the system, and less gain in the remainder of the loop.

For example, Fig. 2 shows a control system used to maintain the thickness of metal sheet. The desired thickness is entered into the controller as a voltage, and the thickness gage measures the thickness as the sheet exits from the rolls. If the sheet is too thick, a difference exists between the gage signal and the voltage which represents the desired thickness. This difference is amplified by the controller with gain K_1 and is sent to the roll positioner which moves the rolls together until the sheet is squeezed to the desired thickness.

Since great accuracy is often desired in systems of this type, the gage must be very sensitive, and the controller gain, K_1, must often be quite high. Gain of these elements is based upon considerations other than system stability. Therefore, to achieve the desired stability, the one remaining element, the roll positioner, is used and it must have a relatively low gain. Hence, it is not only necessary to achieve the desired gain product but also to have the adjustments in the most advantageous location.

Gain in a given device is not always a fixed quantity. The slope of the input-output curve, Fig. 3, denotes the gain at any given input. As the input increases, the gain decreases until the gain is very low at high inputs. Many types of linkages, sine-cosine mechanisms, flapper and nozzle pneumatic-amplifiers, and many other devices have nonlinear gain characteristics.

In determining the stability of a control system, gain at one point, usually the origin, is considered. However, the effect of gain change cannot be ignored, since it may materially affect the operation of the system.

The gain discussed in conjunction with hydraulic systems refers to flow versus displacement in a control valve. Hydraulic control valves are supplied with a source of hydraulic pressure and con-

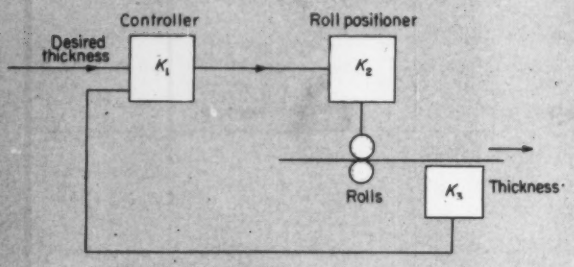


Fig. 2—System for control of sheet thickness. A large amount of gain in one portion of system and a small amount in other portions

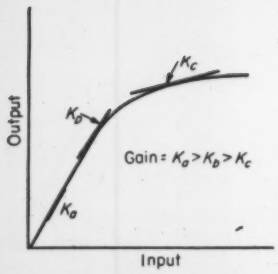
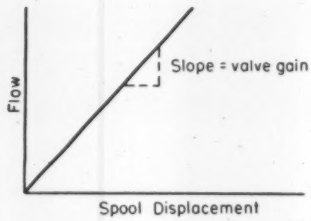


Fig. 3—Slope of input-output curve denotes gain



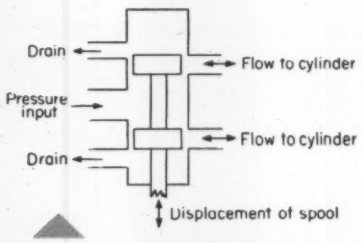


Fig. 4—Flow-displacement characteristics for control valve with constant pressure differential

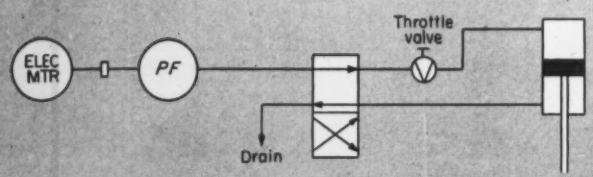


Fig. 5—Throttle valve used to control gain

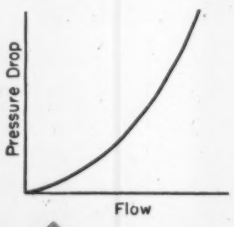


Fig. 6—Pressure drop through throttle valve is proportional to flow squared

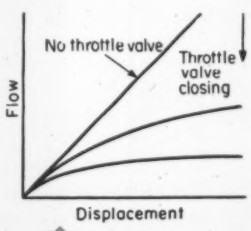


Fig. 7 — Flow-displacement characteristics for control valve modified by throttle valve

trol flow through a port arrangement. Flow usually is directly proportional to the port opening, if the differential pressure across the valve is constant, Fig. 4.

To adjust the flow through control valves, and hence the gain, four types of auxiliary valves can be used. These auxiliary valves and their characteristics are covered in this discussion.

Throttle Valve: The most common device used to control gain in hydraulic systems is the throttle valve, which is placed in a line between the control valve and the cylinder, Fig. 5. As the throttle valve is closed, the speed of the cylinder decreases for a given control-valve displacement. Hence, gain in this portion of the circuit is decreased. However, the throttle valve has a major drawback; the effect of the valve varies with flow.

With turbulent flow through the throttle valve, the pressure drop versus flow characteristic of the valve is shown in Fig. 6. When placed in series with a control valve and a cylinder, the throttle valve alters the gain characteristic of the control valve, Fig. 7, and the gain of the control valve is the slope of the curve.

Theoretically the throttle valve should not affect gain when the control valve is at a center position. Under this condition, the control valve would have an infinitely small port opening while the throttle valve would have a finite opening. Hence, the throttle valve should not affect the slope of the curve at zero displacement.

Practically, stability is achieved because control valves cannot be built with perfectly zero laps and because of the saturation effects introduced by the throttle valve. This latter factor is, however, one of the major drawbacks of this type of gain adjustment. Stability is achieved only with a concurrent limiting of maximum speed.

Stabilizing Valve: One simple means of overcoming the throttle valve saturation effect is through the use of a stabilizing valve, Fig. 8, which is the combination of a check valve and a throttle valve.

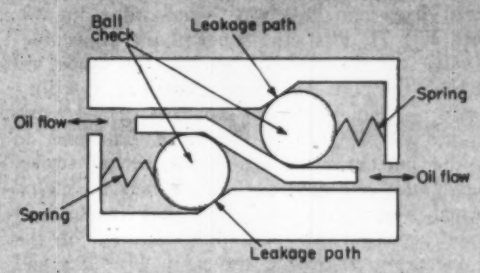


Fig. 8—Stabilizing valve consisting of check and throttle valves in one housing

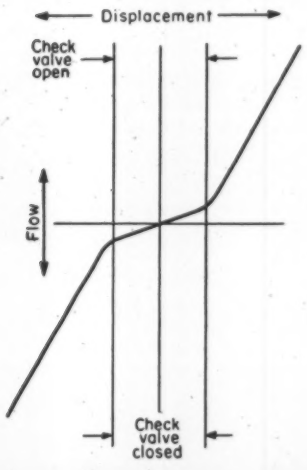


Fig. 9—Flow-displacement characteristics for control valve modified by stabilizing valve

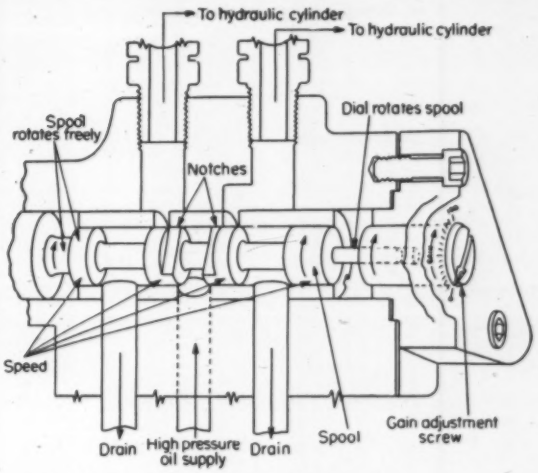


Fig. 10—Adjustable-gain control valve

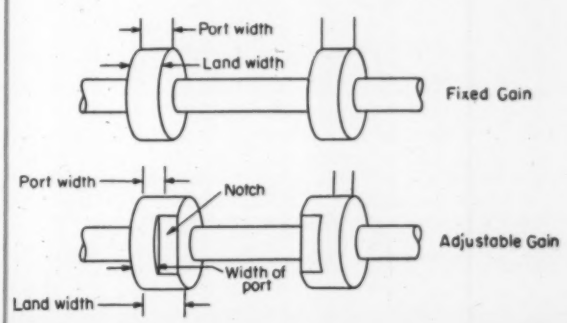


Fig. 11—Spool configurations for four-way control valves

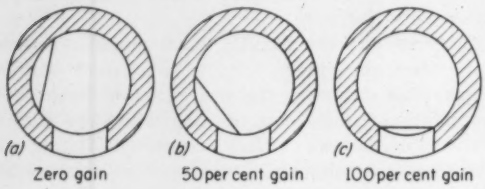


Fig. 12—Position of spool notch in port opening determines gain

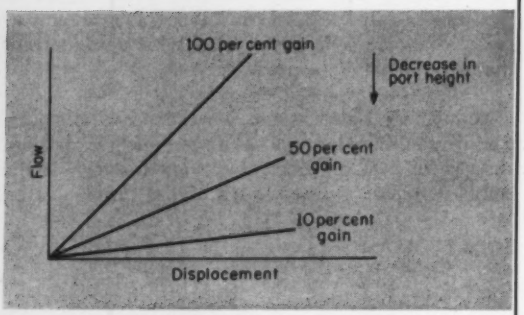


Fig. 13—Effect of gain adjustment on flow-displacement characteristic for adjustable-gain valve

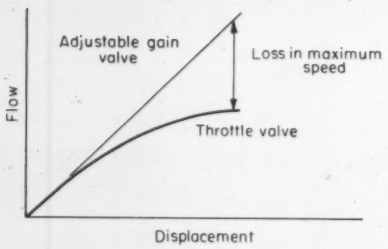


Fig. 14—Increase in speed with stabilization produced by adjustable-gain valve

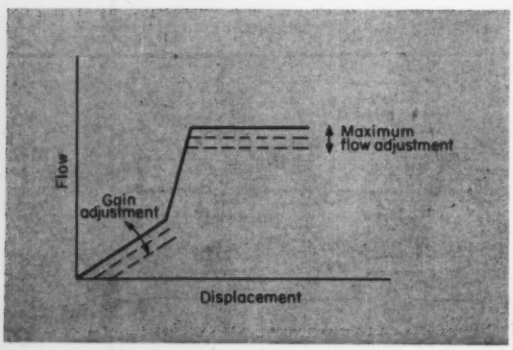


Fig. 15—Flow-displacement characteristics for two-speed adjustable-gain valve

Oil flows in either direction through the valve as indicated by the arrows. Under low-pressure conditions, oil leaks past the ball-check portion of the valve. This leakage is equivalent to the flow through a needle valve which is almost closed. When oil pressure increases, the spring which holds the ball check against its seat is compressed, and large quantities of oil are allowed to pass. When a stabilizing valve is placed in series with a control valve, the low value of gain through the origin increases stability, while the high gain at the outer portions insures high speed operation, Fig. 9.

Gain adjustment is achieved by placing a throttle valve in parallel with the stabilizing valve. The throttle effectively changes the slope of the curve through the origin, but has little effect when the stabilizing valve is wide open.

Adjustable-Gain Control Valve: Another improvement over the throttle valve is the four-way spool valve, Fig. 10, used for adjustable-gain control. Displacement of the spool to the left allows oil to pass from the pressure supply to the left cylinder line. At the same time, a passage opens connecting the right cylinder line to the drain. Displacement of the spool in the opposite direction reverses the direction of flow. For a constant pressure differential, flow is proportional to spool displacement.

The adjustable-gain valve is different from the standard fixed-gain four-way spool valve in two respects, Fig. 11. First, the spool of the adjustable-gain valve can be rotated. Second, the lands are wider than the ports and have a notch on the pressure side of each. When the notch is turned away from the port, Fig. 12*a*, the spool continues to block the port even though displaced full stroke, producing the zero-gain position. When the notch is turned toward the port, the port height and the port opening per unit displacement of the spool increases, increasing the gain, Fig. 12*b* and 12*c*. Fig. 13 shows flow and displacement characteristics of this valve for various gain settings.

The advantage of this valve over the throttle

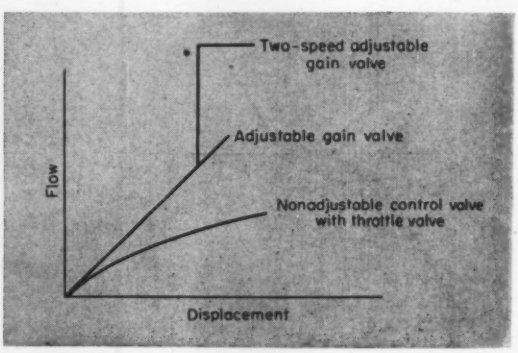


Fig. 16—Comparison of flow-displacement characteristics for three types of gain adjustment

valve is the greater maximum speed available when the valve port is set for the gain required to stabilize the system. Fig. 14 compares a system which uses an adjustable-gain control valve with one which uses a throttle valve. Both systems are set for the same gain at zero flow and, therefore, have the same degree of stability. The system with the adjustable-gain valve achieves up to five times the maximum speed of the other system. The system is not only faster and simpler, but wastes less power.

Two-Speed Adjustable-Gain Valve: An additional feature can be added to the adjustable-gain valve which permits a higher maximum speed. The standard adjustable-gain valve produces a flow proportional to displacement up to the limit of spool stroke. The two-speed valve incorporates a bypass port which opens when the spool is near the end of its stroke. The addition of the bypass port permits a great increase in flow for large spool displacements, Fig. 15. Also, the adjustment is provided at maximum flow as well as for gain at the origin.

Choice of Valve: Fig. 16 shows flow-displacement curves for a two-speed adjustable-gain valve, an adjustable-gain valve, and a throttle valve. Slope of the curves at the origin is the same. Therefore, relative stability is the same. However, maximum flows and resulting cylinder speeds are considerably different. This difference is reflected in improved performance of systems employing the adjustable-gain valves.

Proper choice of valve is complicated by many factors beside speed and stability.

When sufficient data for proper valve sizing are available, the nonadjustable control valve, in conjunction with a throttle valve, is usually the most economical solution. When knowledge of the process cannot be obtained, a more efficient and flexible adjustment may be required. Here, the adjustable-port control valve can save installation time, and in addition, provide increases in the system performance.

Since power consumption is often a factor in the selection of a valve, the throttle valve, which dissipates power, should be avoided. When maximum power transfer is desired, the port height of an adjustable-gain valve can be adjusted.

Stabilizing and two-speed valves are useful when a minimum of noise or cylinder rod dither is required. These valves minimize dither and permit high-speed operation under dynamic conditions.

When gain is adjusted in the flow control portion of the system, stability can be obtained without affecting resolution, sensitivity, or efficiency, by using an adjustable-gain or two-speed valve.

Tips and Techniques

Precise Line Drawings

When lines must be precise on drawings such as blowups for comparator machine checking, a pair of dividers and a piece of carbon paper can be used instead of a lead pencil. The carbon paper is placed carbon-side down on a piece of paper and the lines are drawn on the carbon paper with a divider point. The weight of the divider is sufficient to cause the carbon to be transferred to the paper below. Lines produced are extremely thin and precise, and can be reproduced by normal methods.—E. J. KICK, *Columbus KcKinnon Chain Corp., Tonawanda, N. Y.*

Evaluating Repeating Decimals

To evaluate a repeating decimal simply and accurately, use the equation

$$N = x + \frac{a + \dfrac{b}{10^m - 1}}{10^n}$$

where N = exact value of fractional equivalent, x = whole number of decimal, a = nonrepeating combination of digits of decimal, b = repeating combination of digits of decimal, m = number of repeated digits, and n = number of nonrepeated digits.

EXAMPLE 1: Evaluate $N = 0.707070$. From the equation,

$$N = x + \frac{a + \dfrac{b}{10^m - 1}}{10^n} = 0 + \frac{0 + \dfrac{70}{10^2 - 1}}{10^0}$$

$$= \frac{70}{10^2 - 1} = \frac{70}{99}$$

EXAMPLE 2: Evaluate $N = 8.352707070$. From the equation,

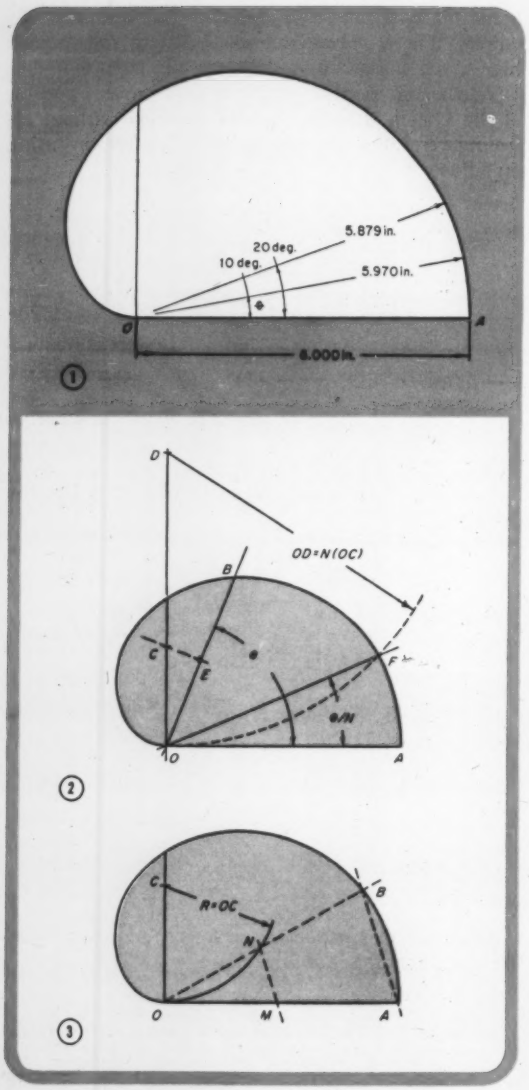
$$N = 8 + \frac{352 + \dfrac{70}{10^2 - 1}}{10^3} = 8 + \frac{352 + \dfrac{70}{90}}{1000}$$

$$= 8\,\frac{34918}{99000}$$

—J. GRADY COX, *associate professor, Alabama Polytechnic Institute, Auburn, Ala.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Multisecting Angles and Rectifying Arcs



An old and unique geometric construction can be used to simplify the dividing of an angle into any number of parts and the rectifying of circular arcs. The construction, a cochloid curve, is based on the formula $R = (A \sin \theta)/\theta$.

Using $A = 6.000$ in. and values of θ between 0 and 180 deg, the curve, Fig. 1, is constructed on a piece of transparent plastic from the values of R in Table 1.

Table 1

θ (deg)	R (in.)	θ (deg)	R (in.)	θ (deg)	R (in.)	θ (deg)	R (in.)
0	6.000	50	5.266	100	3.325	150	1.146
10	5.970	60	4.962	110	2.937	160	0.735
20	5.879	70	4.615	120	2.481	170	0.351
30	5.730	80	4.236	130	2.026	180	0.000
40	5.524	90	3.820	140	1.578		

To Multisect an Angle: An angle θ, Fig. 2, which is to be divided into N equal parts is extended to intersect the cochloid curve template at A and B. A perpendicular is erected at O. The line OB is bisected at E and a perpendicular which intersects the perpendicular to OA at C is constructed. Line OD is then laid off equal in length to $N(OC)$. With D as a center and OD as a radius, an arc is scribed which intersects the cochloid curve at F. The angle AOF is then the angle for one part, O/N, of the multisected angle.

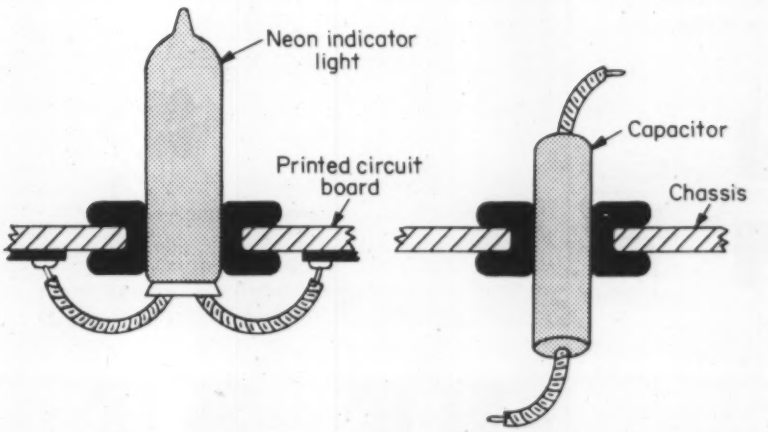
To Rectify an Arc: Line OA of the cochloid curve template is placed perpendicular to line OC to rectify the arc length ON, Fig. 3, for which OC is the radius. The line ON is extended to intersect the cochloid curve at B. The line NM is drawn parallel to the line BA. The straight line OM is equal in length to the length of the arc ON.

—Gustav A. Larson, *engineer, Air Arm Div., Westinghouse Electric Corp., Baltimore, Md.*

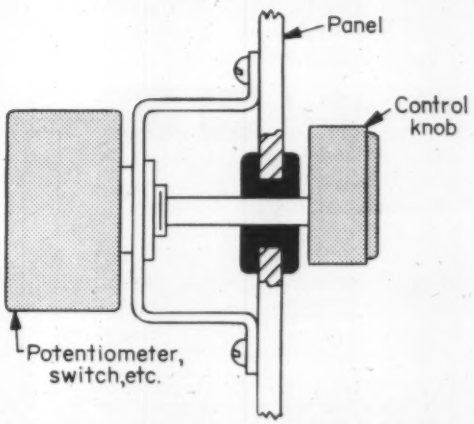
USING RUBBER GROMMETS

By **FRANK WILLIAM WOOD Jr.**
Design Engineer
Servonics Inc.
Alexandria, Va.

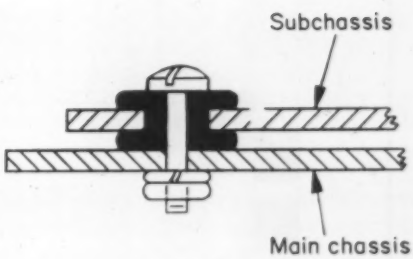
The simpler a part, the more places it can be used. That's true of rubber grommets. At first, grommets protected wires passing through panels. Now, they work well many other ways. Here are nine idea-sparkers.



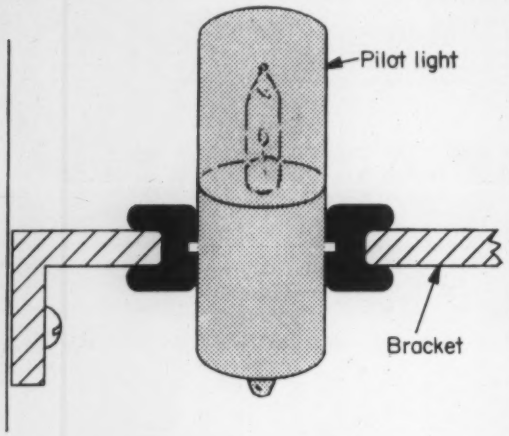
Component Mountings in Chassis



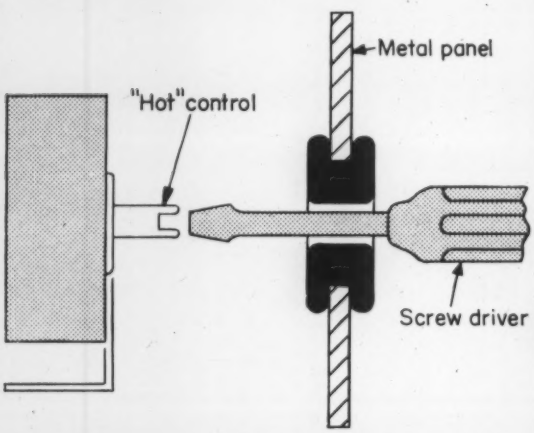
Waterproof Seal for Panel Control Shaft



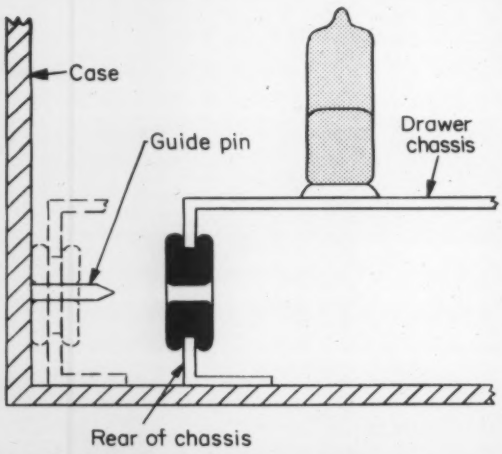
Shock Mounts for Subchassis



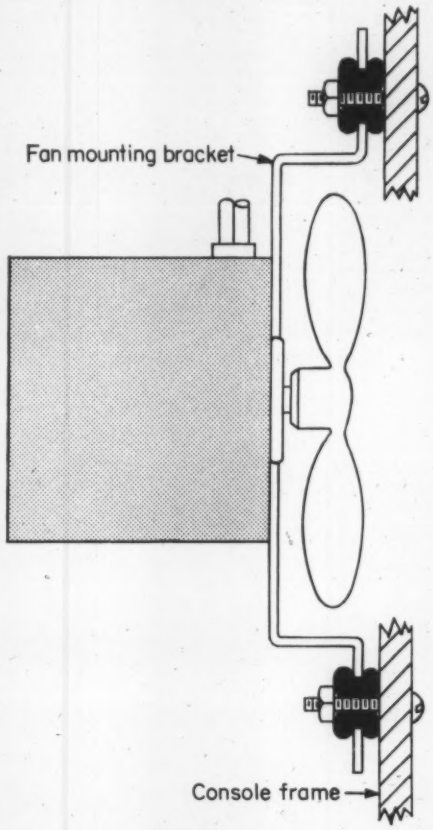
Spare Parts Holder



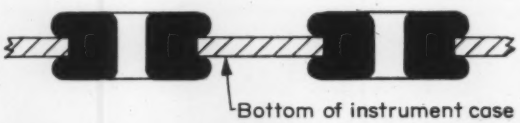
Control Adjustment Insulator



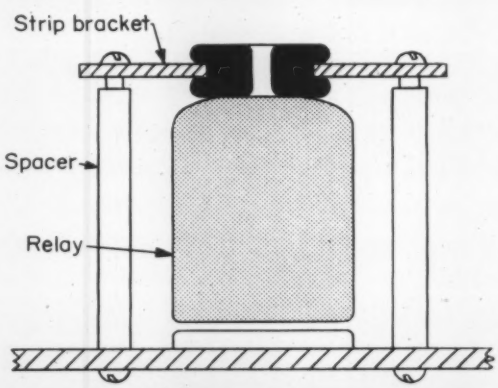
Rattleproof Chassis Guide-Pin Socket



Fan Vibration Damper



Feet for Small Instrument Cases



Cushion Mount for Plug-in Relay

Simplified Column Design

. . . a fast, straightforward method for finding the best cross-sectional dimensions of long, slender members under compression

By HELMUT G. HOESCHEL
Covington, Va.

CRITICAL stress in straight, axially loaded column members is generally expressed as a function of slenderness ratio and material properties. In design, this relationship is often awkward to apply and usually leads to trial-and-error calculations because the slenderness ratio is not known at the beginning of the solution.

This article presents a simplified, direct approach to column design. Tables and a chart provided here eliminate guesswork in design calculations and, also, give a clearer picture of the effectiveness of specific column materials and cross-sectional shapes.

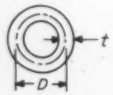
Basic Concepts: A mathematical study of the variables of column design shows that a relationship, similar to that for the slenderness ratio, can be established between critical column stress and certain known design requirements. These known requirements are: Column length, type of end connection, load, factor of safety, material properties, and a so-called shape factor which depends on type and proportions of the column cross section. For simple cross sections—solid round, square, hexagon, etc.—the shape factor is a straightforward constant. For more complex shapes, it must be calculated. A procedure for calculating the shape factor for any cross-sectional shape is outlined in *Shape-Factor Calculations*. Shape factors for a number of commonly used cross sections are given in Table 1.

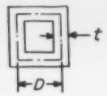
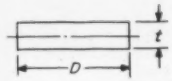
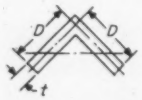
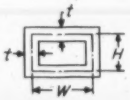
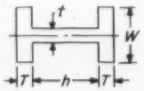
Except for material properties, the known design requirements previously mentioned can be related in the form of a single expression for calcu-

Nomenclature

- A = Area of column cross section, sq in.
- C = Coefficient of constraint for column end connection (Table 2)
- E = Modulus of elasticity of column material, psi
- F = Compressive load along column axis, lb
- I = Moment of inertia of column cross section about the neutral axis, in.^{4}
- k = Radius of gyration of column cross-section (Equation 3), in.
- L = Column length, in.
- N = Factor of safety
- Q = Column design coefficient (Equation 1)
- R = Slenderness ratio (Equation 4)
- s_b = Compressive stress in critical column section due to bending moment, psi
- s_c = Critical column stress, psi = FN/A
- s_e = Equivalent column stress for combined stress calculations (Equation 6), psi
- s_n = Total compressive stress at critical column section (Equation 7), psi
- s_s = Total shear stress at critical column section, psi
- s_y = Compressive yield stress for column material, psi
- s_{ys} = Torsional yield stress for column material (approximately 0.5 to 0.6 s_y), psi
- Z = Shape factor for column cross section = A^2/I
- σ = Maximum combined normal stress, psi
- τ = Maximum combined shear stress, psi

Table 1—Shape Factors and Dimensional Relationships for Typical Column Cross Sections

Form	Shape Factor, Z	Dimensional Relationships
Solid Round		
	12.57	$D = 1.128A^{1/2}$
Solid Square		
	12	$D = A^{1/2}$
Solid Equilateral Triangle		
	10.39	$D = 1.520A^{1/2}$
Solid Hexagon		
	12.47	$D = 1.075A^{1/2}$
Solid Half-Round		
	22.48	$D = 1.596A^{1/2}$
Round Tube		
	$\dfrac{25.13}{n + 1/n}$	$t = [A/(\pi n)]^{1/2}$ $n = D/t$

Form	Shape Factor, Z	Dimensional Relationships
Square Tube		
	$\dfrac{24}{n + 1/n}$	$t = \dfrac{1}{2}\left(\dfrac{A}{n}\right)^{1/2}$ $n = D/t$
Flat Bar		
	$12n$	$t = (A/n)^{1/2}$ $n = D/t$
Equal-Leg Angle		
	$\dfrac{48n}{n^2 + 2.5}$ (approx.) (Error is less than 0.5 per cent if $n \geqq 2.5$	$t = (A/2n)^{1/2}$ $n = D/t$
Rectangular Tubing—Horizontal Axis		
	$\dfrac{24(N + n)^2}{N(3n^2 + 1) + n(n^2 + 3)}$	$t = \left[\dfrac{A}{2(N + n)}\right]^{1/2}$ $N = W/t,\ n = H/t$
I-Beam—Major Axis		
	$\dfrac{12[N(2m - n) + n]^2}{m(1 + N)^3 - (m - n)(1 - N)^3}$	$H = \left[\dfrac{A}{N(2m - n) + n}\right]^{1/2}$ $n = t/H,\ m = W/H,\ N = T/H$
I-Beam—Minor Axis		
	$\dfrac{12(2Nm + n)^2}{2Nm^3 + n^3}$	$h = \left[\dfrac{A}{2Nm + n}\right]^{1/2}$ $n = t/h,\ m = W/h,\ N = T/h$

lating a column-design coefficient. With this coefficient, the critical column stress can be found directly from the chart, Fig. 1. Area of the column cross section can then be determined and the dimensions calculated from relationships given in *Shape-Factor Calculations* or Table 1.

The chart provided here, Fig. 1, is based on Johnson's parabolic column formula for the inelastic range and Euler's formula for the elastic range. It applies to steel. For other column formulas or materials a similar chart can be readily developed by a method which will be discussed later.

Since the approach presented here is merely a mathematical conversion of conventional techniques of column design, the results obtained will be the same as though the conventional methods were used.

Design Procedure: Recommended sequence of steps for design of straight, axially loaded columns is:

1. Select a convenient form of column cross section. If thin walls or flanges are required, the possibility of local wrinkling should be considered. A review of codes, specifications, and the literature[1,2,3,4] is usually advisable in such situations.

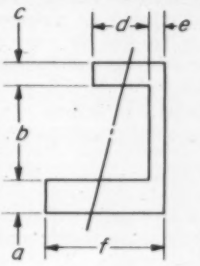
2. Determine shape factor Z. For simple cross-sectional shapes, read Z from Table 1. For complex shapes, compute Z from procedure in *Shape-Factor Calculations*.

3. Find coefficient of constraint C from Table 2.

[1]References are tabulated at end of article.

Shape-Factor Calculations

The following procedure can be used to calculate shape factor Z for any cross section:



1. Choose any convenient set of dimensions, a_o, b_o, c_o, d_o, *etc.*
2. Calculate cross-section area A_o from the dimensions selected in the preceding step.
3. Calculate moment of inertia I_o of the cross section about the buckling axis.
4. Calculate shape factor from

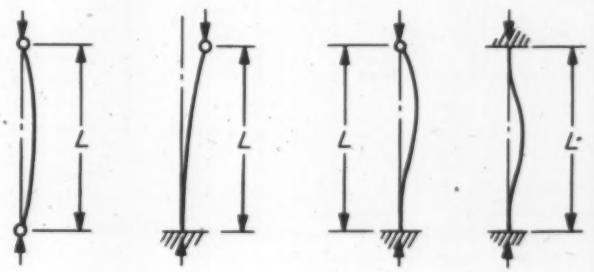
$$Z = \frac{A_o^2}{I_o}$$

General relationship for computing the dimensions of a cross section with the same shape factor Z but different area is:

$$x = x_o \sqrt{\frac{A}{A_o}} = x_o K$$

where x_o represents any dimension of a cross section with area A_o and shape factor Z, and x is the corresponding dimension for a cross section of area A. Thus, $a = a_o K$, $b = b_o K$, etc.

Table 2—Coefficients of Constraint For Different End Connections



Recommended Values				
General design applications	1	1/4	1	1
Recommended Maximum Values				
Very long columns with rigid end connections	...	...	≦1.5	≦2.0*
Experimental Values†				
$L/k = 100$	...	...	1.05	1.13
$L/k = 200$	...	...	1.78	3.0
Theoretical Values‡				
Very long columns	...	...	2	4

*References 4 and 5.
†Reference 6; k = least radius of gyration of section.
‡Not recommended for design.

4. Calculate column design coefficient Q from

$$Q = \frac{L^2 Z}{NFC} \tag{1}$$

5. Read critical column stress s_c from Fig. 1. In the chart, find line corresponding to value of Q computed in step 4. At the intersection of this line with the compressive yield-stress curve for the column material, read corresponding value of s_c from the vertical scale.

6. Calculate required cross-sectional area A from

$$A = \frac{NF}{s_c} \tag{2}$$

If codes or specifications require or suggest a certain maximum permissible slenderness ratio, R_{max}, a slightly modified form of area calculation may be necessary. At the intersection point of the Q and s_y plots found on the chart in step 5, read the corresponding value of slenderness ratio R from the horizontal scale. Ideally, this value should not exceed the required value of R_{max}. However, if it does, compute cross-sectional area A from

$$A = \frac{L^2 Z}{R_{max}^2 C} \tag{2a}$$

7. Calculate dimensions of column cross section from the area found in step 6, using the relationships given in Table 1 or *Shape-Factor Calculations*.

Permissible axial loads on straight columns that are subjected to column stresses only may be computed directly from the chart, Fig. 1, and Table 2. Procedure is:

1. Read coefficient of constraint C from Table 2.

2. Determine radius of gyration k of column cross section from

$$k = \sqrt{\frac{I}{A}} \tag{3}$$

3. Calculate slenderness ratio R from

$$R = \frac{L}{k\sqrt{C}} \tag{4}$$

4. Read critical column stress s_c from Fig. 1. In the chart, locate point corresponding to slenderness ratio R on the compressive yield-stress curve for the column material. Read corresponding value of s_c from the vertical scale.

5. Calculate permissible load F from

$$F = \frac{As_c}{N} \tag{5}$$

Here again, local wrinkling may be a problem under certain conditions. See step 1 of the preceding design procedure for details.

The tables and the chart can also be used for design of columns subject to combined stresses. However, the approach is not as direct as that for columns with axial loads only. Recommended design procedure is:

1. Estimate approximate size and dimensions of column cross section. (Note: See local-wrinkling considerations in step 1 of design procedure for axially loaded columns.)

2. Read coefficient of constraint C from Table 2.

3. Determine radius of gyration k for assumed cross section from Equation 3.

4. Calculate slenderness ratio R from Equation 4.

5. Read critical column stress s_c corresponding to calculated slenderness ratio (step 4) and column-material yield stress from chart, Fig. 1.

6. Calculate equivalent column stress s_e from

$$s_e = \frac{F s_y}{A s_c} \tag{6}$$

where A is the estimated area and s_c is the critical column stress found in the foregoing step.

7. Calculate total normal stress s_n from

$$s_n = s_e + s_b \tag{7}$$

8. Calculate total shear stress s_s at the location where s_n occurs.

9. Calculate maximum shear stress τ from

$$\tau = \sqrt{s_s^2 + \left(\frac{s_n}{2}\right)^2} \tag{8}$$

and/or maximum normal stress σ from

$$\sigma = \frac{s_n}{2} + \tau \tag{9}$$

10. Calculate factor of safety N for the assumed cross section from

$$N = \frac{s_{ys}}{\tau} \tag{10}$$

and/or

$$N = \frac{s_y}{\sigma} \tag{11}$$

depending on whether the shear or normal stress will be used as the criterion for design.

If the computed factor of safety, N, is not satisfactory, repeat steps 1 through 10 with another assumed cross section. Continue this process until a satisfactory solution is found.

Practical Applications: Flexibility of the tables and the chart in column design calculations is apparent from the previous discussion. However, another important feature of this approach is the insight it provides on the effect of modification of column proportions and material. Full range of usefulness of the design procedures is best demonstrated by typical problem solutions.

EXAMPLE 1: A piston rod 24 in. long is subjected to a compressive force of 15,000 lb. Type of application suggests a factor of safety of $N = 4$. Slenderness ratio should not exceed a value of $R_{max} = 200$. Find the required piston-rod diameter if material is SAE 1020 solid-round, cold-finished steel with $E = 30 \times 10^6$ psi and $s_y = 66{,}000$ psi.

From Table 1, shape factor $Z = 12.57$. From Table 2, coefficient of constraint $C = 1$.

From Equation 1,

$$Q = \frac{(24)^2 12.57}{4(15{,}000)(1)} = 0.1207$$

From Fig. 1 at the intersection of $Q = 0.12$ and $s_y =$

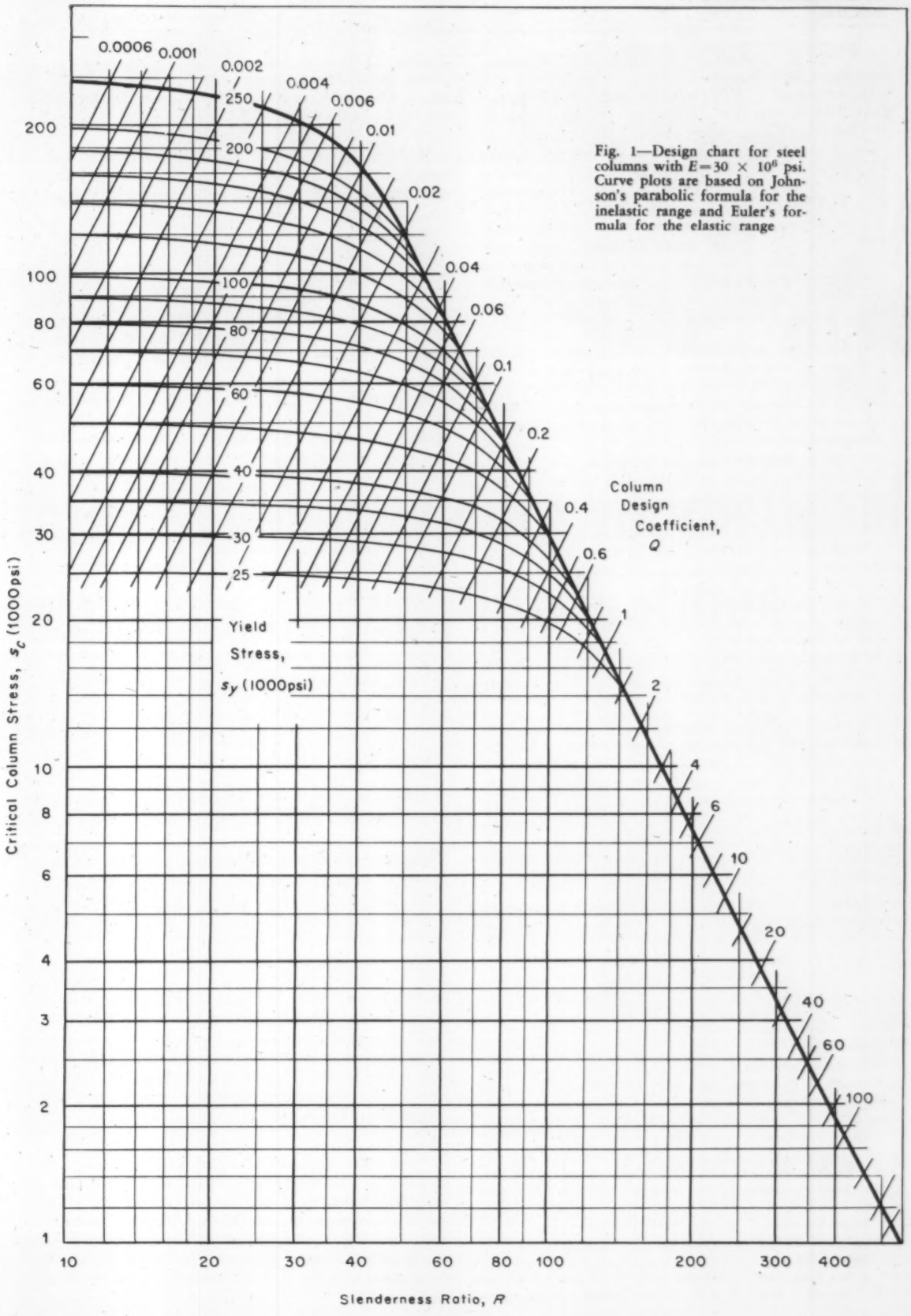


Fig. 1—Design chart for steel columns with $E = 30 \times 10^6$ psi. Curve plots are based on Johnson's parabolic formula for the inelastic range and Euler's formula for the elastic range

66,000 psi, s_e = 45,500 psi and R = 74 which is well within the required limit, R_{max} = 200.

From Equation 2, $A = 4(15{,}000)/45{,}500 = 1.32$ sq in. From Table 1 then, $D = 1.128(1.32)^{\frac{1}{2}} = 1.296$ in. Use $D = 1\frac{5}{16}$ in.

Fig. 1 shows that use of a higher strength steel would increase the critical column stress only about 4000 psi at the most. This increase of approximately 9 per cent also represents the potential reduction in weight that could be realized. If a tubular, rather than solid-round, cross section is used, shape factor Z and column design coefficient Q would both be reduced. This modification would lead to a greater increase in the value of critical column stress and, consequently, to a further reduction in area and weight, particularly for a steel with high yield strength.

EXAMPLE 2: A feed hopper is to be supported by 4 angle-iron posts, each of which carries a compressive load of 30,000 lb. Determine the required size of the angles if the posts are 120 in. high and are structural steel with s_y = 34,000 psi. A factor of safety, N = 2, is considered adequate. Slenderness ratio must not exceed R_{max} = 120. For this application, a practical flange width-thickness ratio is 12:1. End connections should be considered as flexible.

From Table 1, D = flange width $- t/2 = 11.5t$, giving $n = 11.5$. Shape factor $Z \approx 48(11.5)/(11.5^2 + 2.5) \approx 4.10$.

From Table 2, C = 1, and from Equation 1, $Q = 0.98$.

From Fig. 1, s_c = 17,000 psi and R = 130. This value of slenderness ratio exceeds the specified design limit. From Equation 2*a* then, A = 4.10 sq in.

From Table 1, $t = (4.10/23)^{\frac{1}{2}} = 0.422$ in. and flange width = 5.06 in.

If the design limit of R_{max} = 120 can be exceeded slightly, a standard 5 by 5 by $\frac{7}{16}$-in. angle might be used. For this angle, radius of gyration k = 0.98 in. From Equation 4, slenderness ratio R = 122.4.

EXAMPLE 3: A 30-in. connecting link is made from ½ by 2 in. SAE 1020 hot-rolled flat strip steel. Find (1) the ultimate load capacity of the link and (2) the maximum permissible load for factor of safety N = 2.5. Yield stress s_y = 43,000 psi and coefficient of constraint C = 1.

From Equation 3, k = 0.1443 in., and from Equation 4, R = 208. From Fig. 1, s_c = 6800 psi.

Ultimate load $F_u = As_c = 2(\frac{1}{2})(6800) = 6800$ lb, and permissible load $F = F_u/N = 2720$ lb.

EXAMPLE 4: A lever-operated screw jack with a 2-in. nominal-size Acme thread extends to a maximum lift height of 24 in. The load can move laterally. If a force of 100 lb is acting on the 20-in. long lever arm, find the factor of safety under these conditions. The jack is rated for a load of 6000 lb and the screw material is C1045 steel, as rolled, with s_y = 59,000 psi and s_{ys} = 35,400 psi.

For a 2-in. Acme thread, minor or root diameter is 1.75 in. From Table 2, $C = \frac{1}{4}$.

Radius of gyration $k = 1.75/4 = 0.4375$ in. and, from Equation 4, slenderness ratio $R \approx 110$. From Fig. 1, then, s_c = 24,500 psi. Root area of the Acme thread, A = 2.41 sq in.

From Equation 6, equivalent column stress s_e = 6000 psi. Bending moment $M = 100(24) = 2400$ lb-in. and section modulus of the thread root section = 0.526 in.^{3} Compressive stress produced by bending $s_b = 2400/0.526 = 4560$ psi.

From Equation 7, s_n = 10,560 psi. For torque $T = 100(20) = 2000$ lb-in., shear stress is: $s_s = Tc/J = 2000/1.052 = 1901$ psi.

From Equation 8, maximum shear stress τ = 5610 psi. If this stress value is used as the design criterion, then (Equation 10) factor of safety N = 6.31.

From Equation 9, maximum normal stress σ = 10,890 psi. If this stress value is the design criterion, then (Equation 11) factor of safety N = 5.42.

Modified Chart Plots: The approach presented here can be readily adapted to other column design formulas and materials by modifying the chart plot, Fig. 1.

1. Calculate critical column stress s_c for successive values of slenderness ratio R, using the appropriate column design formulas.

2. Plot s_c versus R on logarithmic graph paper in a manner similar to that for chart in Fig. 1.

3. Calculate maximum and minimum values of design coefficient Q for the new chart plot from $Q_{min} = R_{min}^2/s_{c,\,max}$ and $Q_{max} = R_{max}^2/s_{c,\,min}$.

4. Draw a new Q-scale by plotting the expression, $s_c = R^2/Q$, for successive convenient values of the parameter, Q, between the limit values determined in the preceding step, as shown in the present chart, Fig. 1.

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"Unfortunately, it is a habit of many designers, engineers, and others to be reluctant to disclose their lack of knowledge by consulting other people. This is a disastrous outlook, for one should be ready to acquire knowledge constantly throughout one's life for changes in theory and practice over a life time are very great. Those who do not keep themselves in touch with progress easily drop behind. The first essential to being able to keep up with the march of time and science is an intimate knowledge of basic principles. Engineers with a sound basic knowledge in mechanics are less hesitant to consult specialists in other fields, whereas those who have not this knowledge hesitate to consult other people for fear of revealing their ignorance."—SIR GEORGE H. NELSON, *president, Institute of Electrical Engineers.*

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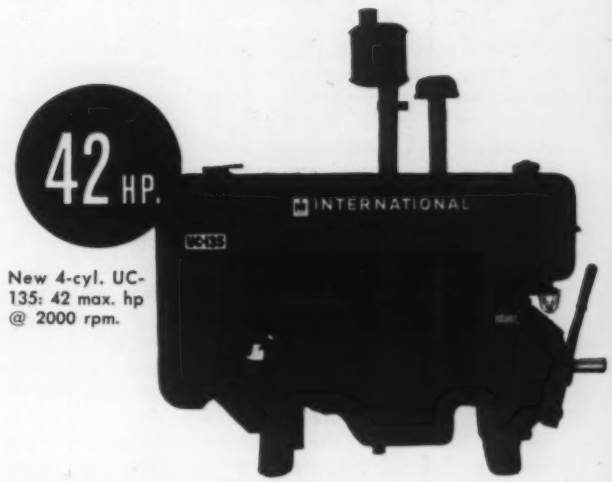

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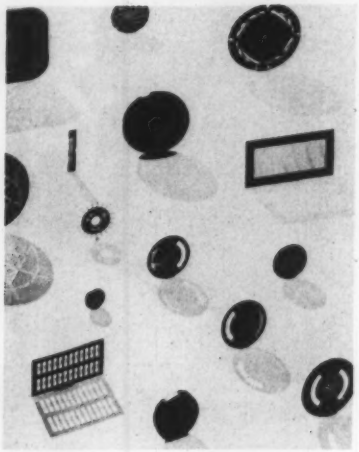

Camera + etching =

Fabrication by Photoforming

ENTIRELY new areas of design have been opened up by a process called "photoforming" in which an acid-resisting photographic image is printed on sheets of metal and the unexposed portion etched away, either chemically or electrolytically. Molybdenum parts made by this method are a commercial reality, tungsten parts have been made successfully, and development work is being done on tantalum with promising results.

Simple Tooling: The "tooling" is merely a well-made mechanical drawing, drawn oversize so that camera reduction minimizes irregularities. In actual practice, it is usually best to let the fabricator make the finished drawing. This is normally done on coated plastic sheet so that dimensional stability is maintained, which is not always possible with paper drawings.

If the design is of a repetitive pattern nature, it is not necessary to draw the entire pattern. "Step-and-repeat" mechanisms can make any desired number of exact duplicates.

Preparation of designs and negatives is less expensive than all but the simplest mechanical tooling. This is of substantial advantage when only a few prototype parts are needed until final designs have been established. Considerable economies are realized in large-quantity production runs.

Physical Properties: The process has no influence whatever on physical properties of the metal. Parts which have been etched can be formed, stamped, or welded in the same manner as unetched metal.

It is a simple matter, for example, to produce a molybdenum grid for an electronic tube by photo forming, Fig. 1. With sheet molybdenum 0.003 to 0.008 in. thick, a blank can be photoformed as shown. The piece is then formed and spot welded. By means of a pattern etched from one side only, serrations or projections, *A*, Fig. 1, can be provided to facilitate spot welding which finishes the part. The grid is then cleaned and hydrogen fired much in the same manner as wire grids.

Precision: One of the outstanding advantages of the process is that all parts are absolutely uniform. There are no tools to wear, and the master printing pattern undergoes no change regardless of the number of pieces produced. Compared with punched or stamped parts, remarkably close tolerances can be maintained. On holes with maximum dimensions to 0.025 in., tolerances can usually be held with-

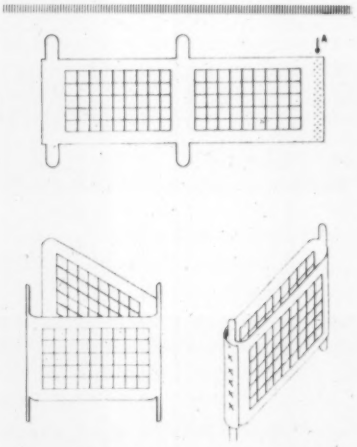

Fig. 1—Molybdenum grid for an electronic tube. The grid is produced as a photoformed blank, top, then bent to shape, and spot welded, bottom, prior to assembly. Many such parts are too thin for successful forming in other ways

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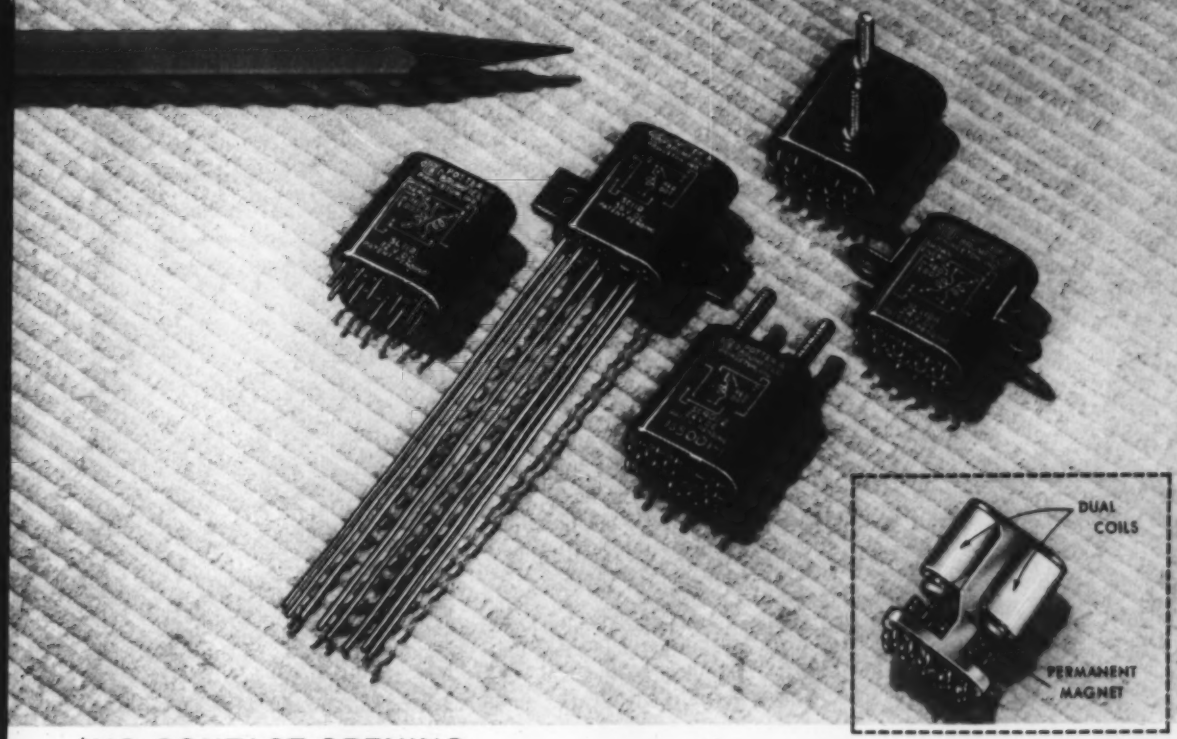

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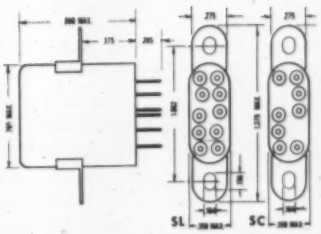

SL—dual coil latching relay. Operates on a 1 watt, 3 ms. pulse at nominal voltage. Permanent magnet latch locks the armature in either position.

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in ±0.0005 in. Photoformed parts are entirely free from burrs. A 2.122-in. OD molybdenum grid was photoformed with tolerances from +0.003 to −0.000 in. Mesh "wires" were 0.010 in. wide and spaced 0.135 in. center to center.

Edges of etched areas are slightly tapered in the direction perpendicular to the surface of the metal. Holes can be produced with a controlled amount of taper according to design requirements by altering the master pattern.

Limitations: Patterns may be of practically any configuration. Designs can be made so that very little or practically all of the metal is etched away. In the present state of the art, thickness of the metal should be between 0.001 and 0.005 in. with 0.010 in. possible at times.

Minimum hole size depends to some extent on pattern configuration but must never be less than the thickness of the sheet. The hole need not be of any geometrical shape such as round or rectangular. Any intricate or unusual configuration is just as easily processed. There are some limitations as to proximity and size of holes depending on metal thickness.

Patterns: Standard mesh patterns from 5 to 1000 mesh lines per in. are currently available. Of these patterns, molybdenum mesh to 133 lines can be fabricated at present. The finer patterns are electroformed from copper, nickel, gold, or silver. One fabricator can supply 3-in. sieves with openings from 20 to 90 mu. The sieves are made of copper and then nickel plated. They are calibrated to ±2 mu from the nominal value.

From "Fabricating Molybdenum by Camera," Fansteel Metallurgy, January, 1959; Fansteel Metallurgical Corp., Metals and Fabrication Div., North Chicago, Ill.

materials

High-Temperature Properties of Iron-Aluminum-Silicon Alloys

D. J. Schmatz and V. F. Zackay, Ford Motor Co.

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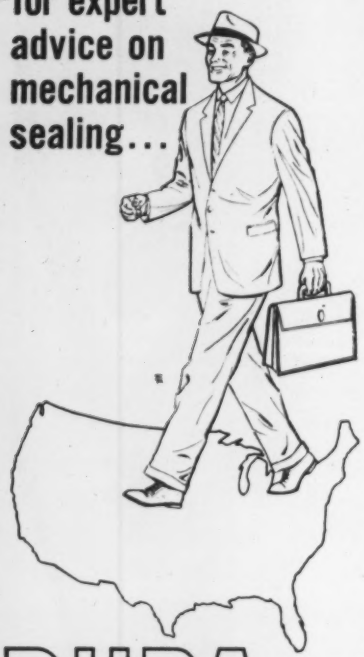

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ties of iron-rich Fe-Al-Si alloys. Silicon is used as the independent variable at three aluminum levels. Desirable properties of the ternary-alloy system containing somewhat less aluminum and silicon, are excellent oxidation resistance, high electrical resistivity, and resistance at elevated temperatures to carburizing and sulphurizing atmospheres. Another advantage of this system is the nonstrategic nature of all three elements. Although the physical and mechanical properties of the Fe-Al and Fe-Si alloys have been studied to some extent, little is known of the ternary composition which might possess sufficient ductility for engineering utilization. These tests were conducted toward that end. Strength and ductility increase and decrease, respectively, with an increase in silicon content at all aluminum levels. Addition of silicon also increases electrical resistivity of the alloys. These alloys behave generally as all ferritic materials and have poor resistance to deformation at elevated temperatures.

ASM paper 111, *ASM Fortieth Annual Convention, Cleveland,* 1958; 11 *pp.*

mechanical

Critical Stresses in Wire Rope

W. L. Starkey, Ohio State University and H. A. Cress, Battelle Memorial Institute

Theoretical analysis of states of stress at critical points of a wire rope. Significant stress in a wire rope is usually believed to be the tensile stress or the stress due to tension and bending. However, the greatest stress results from Hertzian contact stresses. The analysis here asserts that the usual mode of failure of a wire rope is fretting-fatigue initiated at such points of contact. Design relationships based on these concepts should be of value to designers who have occasion to apply wire rope. The authors propose that the probable mode of failure of a wire rope is caused by high contact stresses, especially at regions where wires cross to give point contact, resulting in stresses far greater than yield stress. Yielding and flattening occur, and relative motions of wire contact

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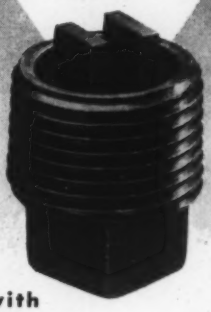

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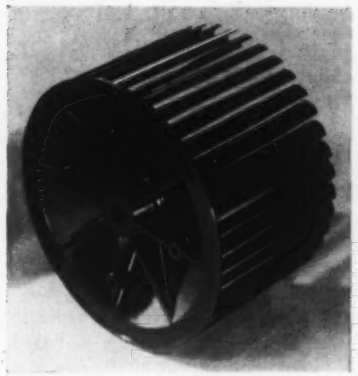

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A. The ring that you'd expect to see steadying the blades at the far end.

Who forgot it? Nobody. In this wheel it's superfluous. Without the ring, air enters the wheel more freely. There's more working blade area. Air flow can be modified at the factory, without retooling, simply by shortening the blades.

You can't make a wheel like this out of metal—not at a marketable price, anyway. But a general-purpose Durez phenolic works fine.

Concentricity is molded in. Wobble is much less than could be achieved economically in a metal wheel. The wafer-edged blades are rigid enough to do without tip support. They can't be bent in shipment or in assembling the blower into any appliance of which it is a part. The wheel withstands moisture and mild corrosive atmospheres; retains its shape through the range of temperatures at which it will operate.

You don't make blower wheels? All right. We're happy if we have implanted an idea for *anything* you might construct better or more cheaply with a Durez general-purpose phenolic. For still more ideas on where and how to apply these durable, versatile materials, send in the coupon requesting Bulletin D400.

Vandalproof

Big-city switchblade artists used to rip the stuffings out of upholstered bus seats—to the tune of $100,000 a year in damage.

Then city transit authorities ordered 330 new buses with glass-reinforced plastic seats like the ones you see here. Made with tough, fire-retardant Hetron® polyester, these seats can't be slashed, defy destruction.

They cost less to make than upholstered seats. And the passengers like them better—voted overwhelmingly in favor of them in rider reaction tests.

Now transit officials plan to replace *all* the city's buses with vehicles featuring these vandalproof seats.

AMERICAN SEATING COMPANY

Where can *you* see a market for strong reinforced-plastic shapes that retard fire? There's a whole family of Hetron resins to help you do your visualizing. Hetron is *inherently* self-extinguishing—gives fire retardance with no loss of mechanical strength. Heat resistance, moisture resistance, electrical properties of Hetron laminates and premix-molded shapes are outstanding.

To get a better idea of what you can do with these fire-retardant resins, use the coupon to request the complete Hetron data file.

KENTILE, INC.

A pinch of permanence

No, cooking does not improve the flavor of this cork tile.

We're just demonstrating the good strong bond that's possible, in a material such as cork, with Durez phenolic resins. Not even boiling water can weaken it.

Locking cork granules together is one of hundreds of bonding jobs these resins can do. You might want to delve into their equally salutory effects on rubber, paper, sand, asbestos, or ground wood.

Under heat, the resin softens, then sets hard, presenting thereafter a permanently stubborn front to heat, moisture, and abrasion. You can get resins that impart many different combinations of useful properties. It doesn't take much resin—often only one part in ten—to get the results you're looking for. And phenolic is one of the lowest-priced bonding agents you can buy.

If you want to know how you might add a pinch of permanence to a product, mail us the coupon. The bulletin you'll receive tells how 12 industries are doing this very thing with Durez resins.

For more information on the Durez materials mentioned above, check here:

- ☐ 8-page Bulletin D400 lists properties, uses, design advantages of general-purpose Durez phenolics and other thermosetting materials.
- ☐ Data file (50A) on Hetron fire-retardant polyester resins.
- ☐ Industrial applications of Durez phenolic resins (12-page bulletin).

Clip and mail to us with your name, title, company address. *(When requesting samples, please use business letterhead.)*

DUREZ PLASTICS DIVISION

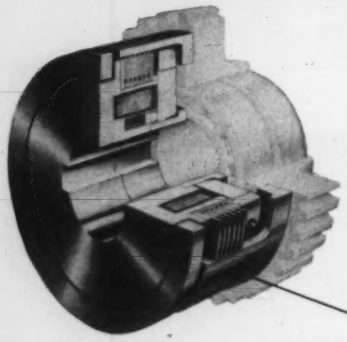
504 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICAL CORPORATION

HOOKER CHEMICALS PLASTICS

Circle 484 on Page 19

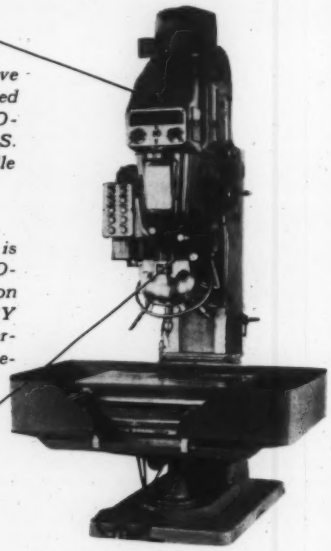
McCauley Electro-Magnetic Multiple Disc and Electro-Magnetic Tooth Clutches were specified for this Brown and Sharpe Turret Drill and Tapping Machine



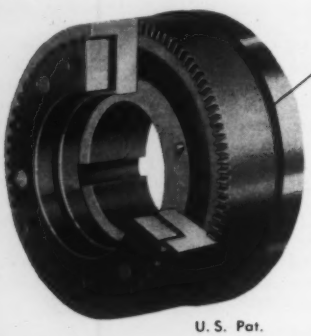
McCAULEY ELECTRO-MAGNETIC MULTIPLE DISC CLUTCHES are supplied in torque ratings from 10 to 16,000 ft. lbs. and incorporate the following features:

- Magnetic isolation of disc stack by using discs of non-magnetic material
- Suitable for wet or dry operation
- Bolt-on design accomplished through simple mounting adapter
- Slip ring or stationary field design

Output of the turret drill variable speed drive is coupled to the main spindle through geared transmission and McCAULEY ELECTRO-MAGNETIC MULTIPLE DISC CLUTCHES. The McCauley clutches are used for spindle reversal in tapping operations.



Double worm reduction for power feed drive is coupled to quill by McCAULEY ELECTRO-MAGNETIC TOOTH CLUTCH. At completion of stroke, limit switch signals McCAULEY power feed clutch. Clutch disengagement, determined by depth stop settings, causes quill retraction.



U. S. Pat.

McCAULEY ELECTRO-MAGNETIC TOOTH CLUTCHES are supplied in torque ratings from 40 to 4,000 ft. lbs. and incorporate the following features:

- Extremely high torque transmission with reference to overall dimensions
- Absolutely no idle torque
- Engagement up to 300 RPM relative speed
- Disengagement under full load while running at maximum RPM
- Bolt-on design accomplished through simple mounting adapter

See the McCauley Display at DESIGN ENGINEERING SHOW, Convention Hall, Philadelphia, Booth No. 1152.

Write for Tooth Clutch Bulletin No. 358 and Disc Clutch Bulletin No. 690.

McCAULEY

INDUSTRIAL CORPORATION • Power Transmission Division
1820 Howell Avenue, Dayton 17, Ohio • AMherst 3-3541

cause fretting which induces fatigue cracks. These cracks first propagate through the highly stressed regions near the points of contact. By the time they propagate out of the highly stressed contact regions, they are sufficiently large that they continue to propagate under less severe tensile and bending stresses. Thus, fretting - induced fatigue cracks propagate to cause complete failure of individual wires.

ASME paper 58-A-63, ASME Annual Meeting, New York, December, 1958; 5 *pp.*

Suppressing Engine-Exhaust Noise

R. Kamo, Armour Research Foundation

A reasonably simple method for predicting with some accuracy the frequency spectrum and intensity of the noise emitted from the exhaust of any internal-combustion engine. Suppression of engine-exhaust noise is by means of a low-pass acoustic filter, the design of which is based on harmonic analysis of the periodic engine-exhaust pressure variation. The Fourier frequency spectrum thus obtained for pressure data exhibits excellent agreement with the experimental sound spectrum. Calculation of cut-off frequencies and the expected degree of silencing as a function of frequency are presented for various types of mufflers. An example for the harmonic analysis and suppression of exhaust noise from a single cylinder, two-cycle gasoline engine is included.

ASME paper 58-A-144, *ASME Annual Meeting, New York, December,* 1958; 16 *pp.*

Four-Bar Linkages—Approximate Synthesis

W. W. Worthley, United Aircraft Corp., and R. T. Hinkle, Michigan State University

An analytical method for synthesizing a four-bar linkage as a function generator. The method, based on a graphical solution, permits arbitrary selection of four precision points and finite angular ranges. This allows a preliminary graphical investigation of the six possible linkages before selecting one for analytical treatment. Although a graphical solution is not necessary before solving for the linkage mathematically, one can be made

in a few minutes and examined for suitability. If the linkage has undesirable characteristics, a second solution can be made by considering the point reduction of another combination of any two precision points. If desired, all six solutions of the linkage for the assumed precision points can be made graphically before selecting one to be solved analytically. Derivation of the point reduction of a single combination of points is included as an example.

ASME paper 58-A-130, *ASME Annual Meeting, New York, December,* 1958; 4 *pp.*

Effect of Mean Stress On Fatigue of Metals

W. N. Findley, Brown University

Development of a theory which shows that alternating shear stress is the primary cause of fatigue in metals with the normal stress on the critical shear plane as an influencing factor. The theory is developed for the case of static stresses superimposed on combinations of torsional and axial load or bending. It is an extension of an earlier theory which discussed the effect of normal stress acting on the plane of failure in fatigue. Predictions of this theory are consistent with known trends of fatigue data for ductile metals and cast iron. They explain the fact that the influence of mean stress is weak for torsion and stronger for bending of ductile metals, but strong for both torsion and bending of cast iron. As far as is known, this is the first rational theory for the influence of mean stress.

ASME paper 58-A-61, *ASME Annual Meeting, New York, December,* 1958; 5 *pp.*

TO OBTAIN COPIES of papers or articles abstracted here, write directly to the following organizations:

Fansteel Metallurgy Fansteel Metallurgical Corp., Metals & Fabrication Div. ,North Chicago, Ill.

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; papers 40 cents to members, 80 cents to nonmembers.

ASM—American Society for Metals, 7301 Euclid Ave., Cleveland 3, Ohio.

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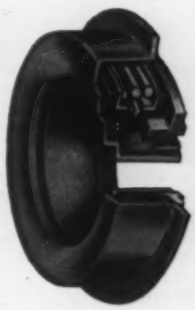
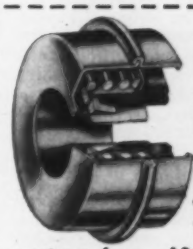


TYPE 6-A

Pressed-in packaged unit recommended for small shafts on hot or cold water, oil, gasoline or soapy liquids . . . pressures to 75 psi . . . temperatures from —65° F. to +220° F. Available in stainless steel or bronze.

TYPE 11-A

Pressed-in packaged unit with spring inside synthetic rubber bellows to protect against corrosion. For hot or cold water, oil, gasoline or soapy liquids . . . pressures to 35 psi . . . temperatures from —65° F. to +212° F.



TYPE 9-A

Packaged unit with wedge sealing ring made of DuPont Teflon. Will handle practically all known industrial chemicals and corrosives . . . pressures to 150 psi . . . temperatures from —120°F. to +500° F. Supplied in metallurgical specification best suited to the service.

Crane Packing Co., 6425 Oakton St., Morton Grove, Ill. (Chicago Suburb)
In Canada: Crane Packing Co., Ltd., Hamilton, Ont.

John Crane

CRANE PACKING COMPANY

Helpful Literature
for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Flexible Shafting

Advantages and simplicity of designing a flexible shaft into products requiring control from a remote point is explained briefly in illustrated Catalog 539. Specification charts on remote control and power drive cables and data on adapters are included. 8 pages. F. W. Stewart Corp., 4311 Ravenswood Ave., Chicago 13, Ill. J

Circle 601 on Page 19

Sealing Washers

Positive sealing against moisture and gases is function of Bartite sealing washers, described in illustrated folder. They make any threaded fastener leakproof. 4 pages. Bartite Products Corp., Everett 49, Mass. B

Circle 602 on Page 19

Flexible Metal Hose

Ways to overcome flexation and vibration problems of diesel pipeline connections are outlined in data sheet on Allflex flexible metal hose. Typical installations are diagrammed, and specifications of available units are given. 4 pages. Allied Metal Hose Co., 3753 Ninth St., Long Island City 1, N. Y. D

Circle 603 on Page 19

Variable Speed Pulleys

Technical data for five MS variable speed sheaves with 2 to 15-hp ratings are contained in Bulletin 4101. Power is transmitted from the stationary flange through a removable sleeve cap which is keyed to the moving flange by resilient rubber keys. 12 pages. T. B. Wood's Sons Co., Chambersburg, Pa. E

Circle 604 on Page 19

Temperature Controllers

Various housing and switching arrangements available for the Series 541 indicating temperature controllers are described in Bulletin MC-176. Ranges from −150 to 700° F and current ratings up to 20 amp, 125 v ac are covered. 4 pages. Fenwal Inc., Pleasant Street, Ashland, Mass. B

Circle 605 on Page 19

Actuators & Resolvers

Descriptions, features, and engineering data on a rotary actuator, miniature linear actuator, single resolver, and triple resolver are included on four data sheets. Typical installation drawings are also included. 2 pages each. Lear, Inc., Box 688, Grand Rapids, Mich. H

Circle 606 on Page 19

Speed Reducers

Universal worm gear speed reducers, designed to operate in three different positions, are subject of Folder 2724. Service factors, load classes, input horsepower ratings, and other data on the units with external cooling fins are included. 8 pages. Link-Belt Co., Prudential Plaza, Chicago 1, Ill. J

Circle 607 on Page 19

Vaneaxial Fans

Technical details of the Series 1000 Axivane fans are presented in illustrated Bulletin J-611. It includes 136 models in 19 housing diameters, 4 hub sizes, 24 motor frame sizes, and five speeds. Specifications and typical applications for the vaneaxial adjustable blade fans are covered. 16 pages. Joy Mfg. Co., Oliver Building, Pittsburgh 22, Pa. F

Circle 608 on Page 19

Metering Pumps

Four models of Masterline metering and proportioning pumps have capacities from a fraction of a gallon to 1030 gph. Features of the pumps are described and typical uses covered in illustrated Bulletin 900. Capacities, pressures, and other data on single and two-feed models are given in Bulletin 902. 6 and 4 pages. Hills-McCanna Co., 4600 W. Touhy Ave., Chicago 46, Ill. I

Circle 609 on Page 19

Locking Bolts & Screws

Long-Lok self-locking bolts and screws resist vibration, are adaptable to special parts, prevent leakage between threads, and are reusable, according to illustrated catalog. Where and when to use them and how to specify them are covered. 8 pages. Long-Lok Corp., 2601 Colorado Ave., Santa Monica, Calif. L

Circle 610 on Page 19

Photovoltaic Cells

Over 25 standard selenium photovoltaic cells are described and illustrated in Bulletin PC-649A which describes their structure and operation, performance characteristics, output current curves, and typical applications in many fields. 8 pages. International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif. L

Circle 611 on Page 19

Plastic Tubing

Prices, tolerances, sizes, and application data on polytetrafluoroethylene (PTFE) tubing are found in folder. A gate-fold chart lists electrical, mechanical, chemical, and thermal properties. Comparison charts for other tubing are included. 4 pages. Minnesota Mining & Mfg. Co., Irvington Div., 900 Bush Ave., St. Paul 6, Minn. J

Circle 612 on Page 19

Magnetic Conveying

Permanent magnetic components designed for belt conveying systems are described in series of illustrated specification sheets found in file folder "Magnets for Automation." Details of permanent magnetic Magna-Rails, Magna-Rolls, and several typical applications are included. Eriez Mfg. Co., Erie 6, Pa. F

Circle 613 on Page 19

Brazing Alloy

Nicrobraz nickel base brazing alloy for joining stainless steel surfaces with large clearances is subject of Engineering Data Sheet No. 5. Composition, metallurgical properties, and engineering properties are listed, along with application data. 1 page. Wall Colmonoy Corp., 19345 John R St., Detroit 3, Mich. H

Circle 614 on Page 19

Rotary Pumps

Rotor, pump casing and head, bearing, bearing housing, axial rotor adjustment, stuffing box, and shaft specifications are given in illustrated Bulletin 1550 on heavy duty internal gear rotary pumps. Typical application data are given for the pumps, rated at up to 1000 gpm. 2 pages. Deming Co., Salem, Ohio. G

Circle 615 on Page 19

Mobile Copying Camera

The Peerless Copy-Cart, a mobile copying camera, is especially suited for companies that are large users of photocopies. It can handle, for instance, about 1500 check-sized originals per hour. Copying procedure is described in Bulletin SL-12. 8 pages. Peerless Photo Products, Inc., Shoreham, Long Island, N. Y. D

Circle 616 on Page 19

Tantalum Capacitors

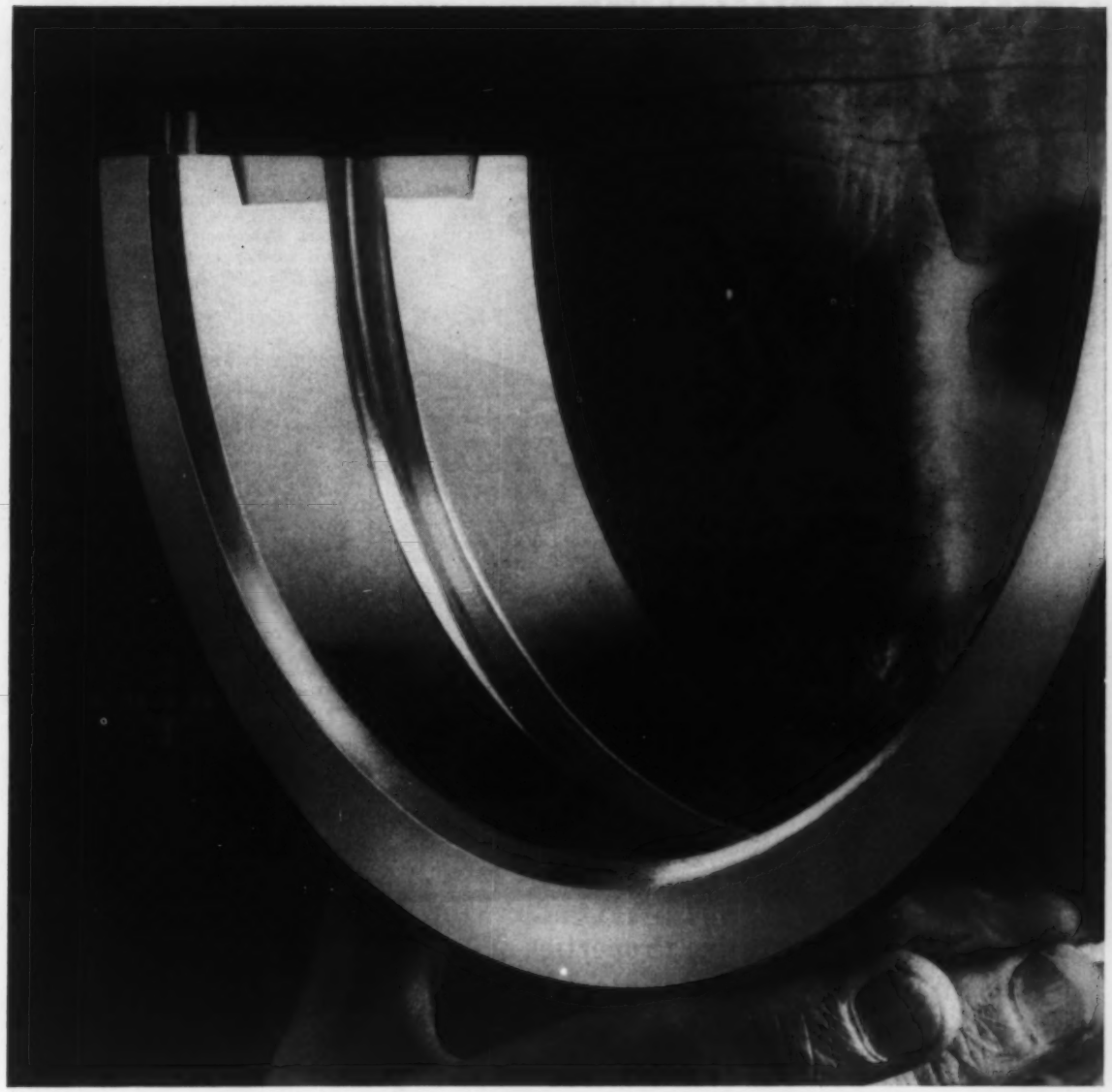
"What to Expect from Tantalum Capacitors" is title of booklet which discusses their capabilities and limitations under various electrical and electronic service conditions. Text covers temperature, frequency, surge voltage, shock and vibration conditions, and results of life tests. 12 pages. Fansteel Metallurgical Corp., Dept. MDC, North Chicago, Ill. J

Circle 617 on Page 19

Motor Protector

Operation of the Type T automatic reset motor protector is outlined in illustrated Bulletin MOPR-4. It offers overtemperature protection against many causes. Application details are given. 2 pages. Metals & Controls Corp., Spencer Div., Attleboro, Mass. B

Circle 618 on Page 19



Alcoa Aluminum is today's best buy for bearings!

Here are the facts and figures for today's alert designers

Alcoa® Aluminum alloys do a *better* job in virtually every way. Strong words? Here are *facts* to back them:

Solid aluminum bearings, being nonmetallic in construction, protect costly shafts. Rugged service in a host of applications from railroads to rolling mills has proven their unmatched load-carrying ability. This means that with the same size bearing you can design for higher engine output. Or, if engine output is to remain the same, you can use a smaller bearing of aluminum and gain design advantages, such as: shorter and stiffer crankshafts, smaller and more compact engines and increased hp per cubic inch. In addition, aluminum bearings . . . RUN COOLEST of *all* bearing metals, because aluminum is the best heat conductor. Actual tests show heat reductions up to 20°F.

ALUMINUM BEARINGS last longest, because ductile aluminum *conforms* readily to misaligned shafts . . . has ideal *embeddability* for gritty particles . . . *resists corrosion* without additional protective coating . . . and is totally unaffected by the additives in today's lubricating oils.

ADD TO the list the fact that aluminum has very low starting friction under heavy load, high corrosion resistance and flexibility of design and manufacture. Then you have today's best buy in bearings. For the whole story, call Alcoa, or write 1837-D Alcoa Building, Pittsburgh 19, Pa.

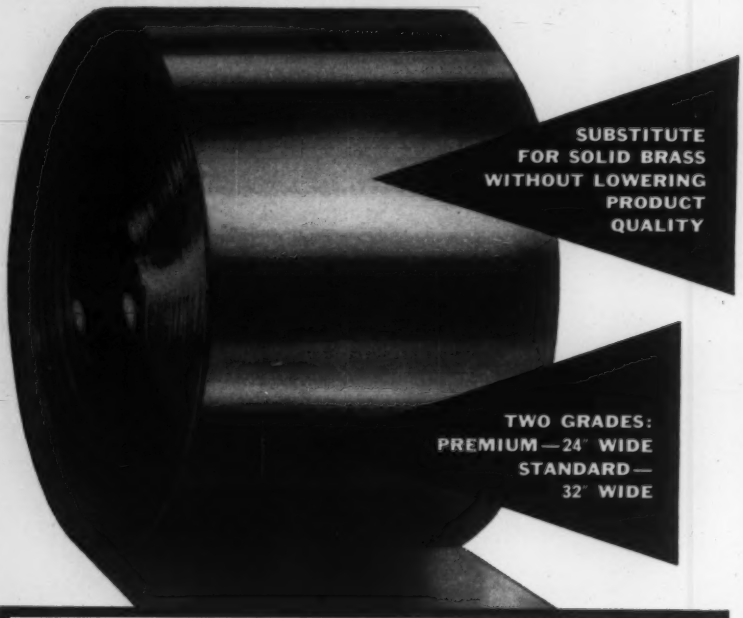
Now available—Alcoa Aluminum bushing stock! Call your nearest Bunting distributor.

ALCOA ALUMINUM

Your Guide to the Best in Aluminum Value

For Exciting Drama Watch "Alcoa Theatre," Alternate Mondays, NBC-TV, and "Alcoa Presents," Every Tuesday, ABC-TV

NEW PRE-FINISHED BRASS-STEEL SAVES 25% OR MORE ON MATERIAL COSTS



Combines the Decorative Properties of Brass With the Economy of Steel

Where the only BRASS you *need* is the brass you *see*, save 25 percent or more on material costs, reduce production steps with brass-plated steel. This way, the only BRASS you pay for is the substantial brass coating you *really need*. Big 32" wide coils — the widest ever made — in Standard grade, for utility or decorative uses; 24" wide in Premium grade, our finest quality — an economical substitute for pure brass for many applications. Both grades are sealed with BAKEKOTE, a baked resin film. Mar-Not protective coating protects the pre-finished surface during fabrication. Big 24" and 32" wide coils and sheets — bright and satin finishes and crimps. Also stripes in sheets, only.

UNPOLISHED — For those parts designed beyond the fabrication limits of our regular pre-finished material, consider *unpolished* Brass-Steel. Excellent for post-finishing work or for applications where high surface finish is not required.

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HELPFUL LITERATURE

Motors

"1959 Motor Application Guide" describes nine major factors in motor selection. Polyphase, single-phase, and direct current motor selection charts cover typical motor driven equipment and their starting and running torques, load characteristics, speeds, capacities, and other factors. Gearmotors and selective speed drives are also covered. 16 pages. Century Electric Co., 18th & Pine Streets, St. Louis 3, Mo. I

Circle 619 on Page 19

Nonferrous Tube & Shapes

"The Measure of Tubemanship" brochure will acquaint readers with the combination of skills and techniques necessary to manufacture seamless copper and copper alloy tubing. It covers facilities, quality control, and creativity in development. 18 pages. Calumet & Hecla, Inc., Wolverine Tube Div., 17200 Southfield Rd., Allen Park, Mich. H

Circle 620 on Page 19

Multiple V-Belt Drives

"The Modern Way to Design V-Belt Drives" is title of Catalog DH-900 which provides drive design data on the compact Super HC V-belt drive. Tables show how to handle both stock and nonstock drives with the HC V-belt which has up to three times the horsepower carrying capacity of previous belts. 32 pages. Gates Rubber Co., 999 S. Broadway, Denver 17, Colo. K

Circle 621 on Page 19

High-Tensile Fastening

Aid to the selection of appropriate nut and bolt combinations for high tensile applications is provided by Design Manual No. 5825. It covers fastener design; NAS and MS bolt specs; cross reference of 160,000, 180,000, and 220,000-psi bolts and stop nuts; and a set of self-locking fastener standard drawings. 38 pages. Elastic Stop Nut Corp. of America, Union, N. J. D

Circle 622 on Page 19

Manometers

"Manometers—Theory and Application" is an illustrated manual on the principles and terminology encountered in manometry. Conversion tables for various manometer fluids are included. Applications of these instruments for pressure, flow, differential, and other indications are covered. 8 pages. Dynametrics Corp., Northwest Industrial Park, Burlington, Mass. B

Circle 623 on Page 19

Stainless Tubular Products

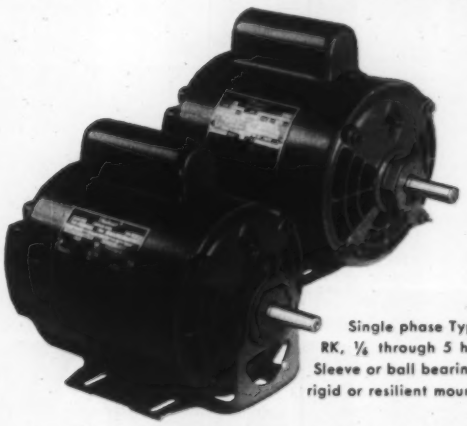
Folder TDC-190 contains technical data on analyses, corrosion and oxidation resistance, high and low temperature characteristics, and physical and mechanical properties of 18-8 stainless steel. It covers tubing and pipe, welding fittings, and flanges. 8 pages. Babcock & Wilcox Co., Tubular Products Div., 161 E. 42nd St., New York, N. Y. C

Circle 624 on Page 19

Need all-angle operation?

WAGNER CAPACITOR-START MOTORS

operate in ANY position... provide dependable starting...
pack more power into less space!



Single phase Type RK, ⅙ through 5 hp. Sleeve or ball bearing. rigid or resilient mount.

Here's the answer for applications that require angle mounting of fhp motors. Wagner Type RK sleeve bearing motors, in fractional ratings, have a positive lubrication system that permits operation in any position.

You get quick, trouble-free starts—thanks to a Wagner designed quick break switch—and you get more horsepower with less bulk, for a better chance to lick those tough space problems.

You can get these motors from leading motor distributors in your community and from Wagner Sales Offices in 32 principal cities. Your Wagner Sales Engineer will be glad to help you select the right motor for your application. Wagner Bulletin MU-217 gives full details.

WM59-6

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Wagner Electric Corporation

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SERVING 2 GREAT GROWTH INDUSTRIES... *ELECTRICAL... AUTOMOTIVE*

New features in an all new

electro-permanent magnetic

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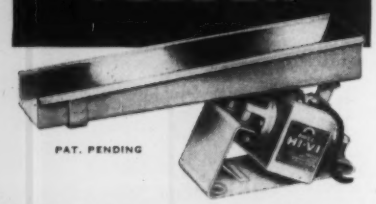
HI-VI VIBRATORY FEEDER



Here's the feeder *you** helped design! Provides accurate, uniform rate of feed of bulk materials – variable from ounces to tons. For spreading, sorting, aerating, cooling, proportioning, mixing, etc. Increases production, reduces maintenance.

TOTALLY ENCLOSED DRIVE ELEMENT FOR LONGER COIL LIFE • NO RECTIFIER NEEDED • SIMPLE INSTALLATION • JUST PLUG OR WIRE INTO A.C. LINE • NEW GLASS FIBER SPRINGS REDUCE BREAKAGE • NEW ELECTRO-PERMANENT MAGNETIC DRIVE PROVIDES GREATER FEEDING CAPACITY THAN COMPARABLE SIZE UNITS • PRE-TESTED AND STABILIZED AT FACTORY.

Industry Users —

ALSO AVAILABLE: Economical, specially constructed units for hazardous, dusty locations . . . fully acceptable by Mill Mutual.

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Eriez Mfg. Co., 131-RB Magnet Drive, Erie, Pa.

ERIEZ

Circle 490 on Page 19

HELPFUL LITERATURE

Welding Nuts

Many ways in which welding nuts save time and labor in both fabricating and assembly while they simplify the fastener access problems are demonstrated in Folder 7764. One section deals with requirements imposed by special products. 4 pages. Midland-Ross Corp., Owosso Div., Owosso, Mich. H

Circle 625 on Page 19

Synchronous Motors

Design features, construction, and applications of constant speed motors for commercial and industrial use are reviewed in Bulletin GEA-6814. Manufacturing techniques and typical installations of these high-speed synchronous motors are shown. 4 pages. General Electric Co., Schenectady 5, N. Y. C

Circle 626 on Page 19

Machinery Mounting Pads

Information on installation of machinery on Unisorb vibration mounting pads is provided in folder. Recommendations are given on the type, densities, and thicknesses of Unisorb pads required for various types of machines. 6 pages. Felters Co., Unisorb Div., 210 South St., Boston, Mass. B

Circle 627 on Page 19

Welding Products

Informative guide to welding practice embodies a catalog of company's line of stainless, low-alloy, non-ferrous rods and electrodes for manual automatic and semi-automatic welding. Technical guidance on successful welding performance is also provided. 32 pages. Arcos Corp., 1500 S. 50th St., Philadelphia, Pa. E

Circle 628 on Page 19

Ball Valves

Metal-to-metal seats and minimal envelope dimensions are features of Venturi-Flow ball valves described in Data Sheet WF 1538. Valves find application in fluid systems employing corrosive fluids and fuels. 2 pages. F. C. Huyck & Sons, Waldorf Fluid Systems Div., Wolf Hill Road, Huntington Station, Long Island, N. Y. D

Circle 629 on Page 19

Gasoline Engines

Bulletins E-301-A, E-303-A, and E-305-A, respectively, describe four, six, and three-cylinder models of new interchangeable Hercules engines designed for use with gasoline, kerosene, LP-gas, or natural gas. 2 pages each. Hercules Motors Corp., 101 11th St. S.E., Canton 2, Ohio. G

Circle 630 on Page 19

Circuit Breakers, Switches

General products Bulletin 3-610 covers application and construction details of oil circuit breakers, subway switches, precision balances, rotary switches, and panel and portable instruments. Breakers range from 50,000 to 250,000 interrupting kva. 8 pages. Federal Pacific Electric Co., 50 Paris St., Newark 1, N. J. E

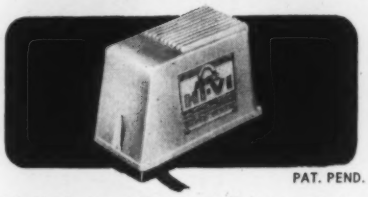
Circle 631 on Page 19

UNSTICK stuck BINS

with new electro-permanent magnetic

ERIEZ

HI-VI VIBRATORS



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Here's the newest and most efficient answer to those hard-to-move materials in sticky bins . . . designed to provide superior operating efficiency . . . exclusive pinpointed vibration gets right to the trouble spot – starts stubborn materials moving!

NO RECTIFIER NEEDED • COMPLETELY ENCLOSED HOUSING • GREATER VIBRATION IMPACT THAN COMPARABLE SIZE UNITS • RUGGED AND DURABLE • LOW FIRST COST • LOW OPERATING AND MAINTENANCE COST.

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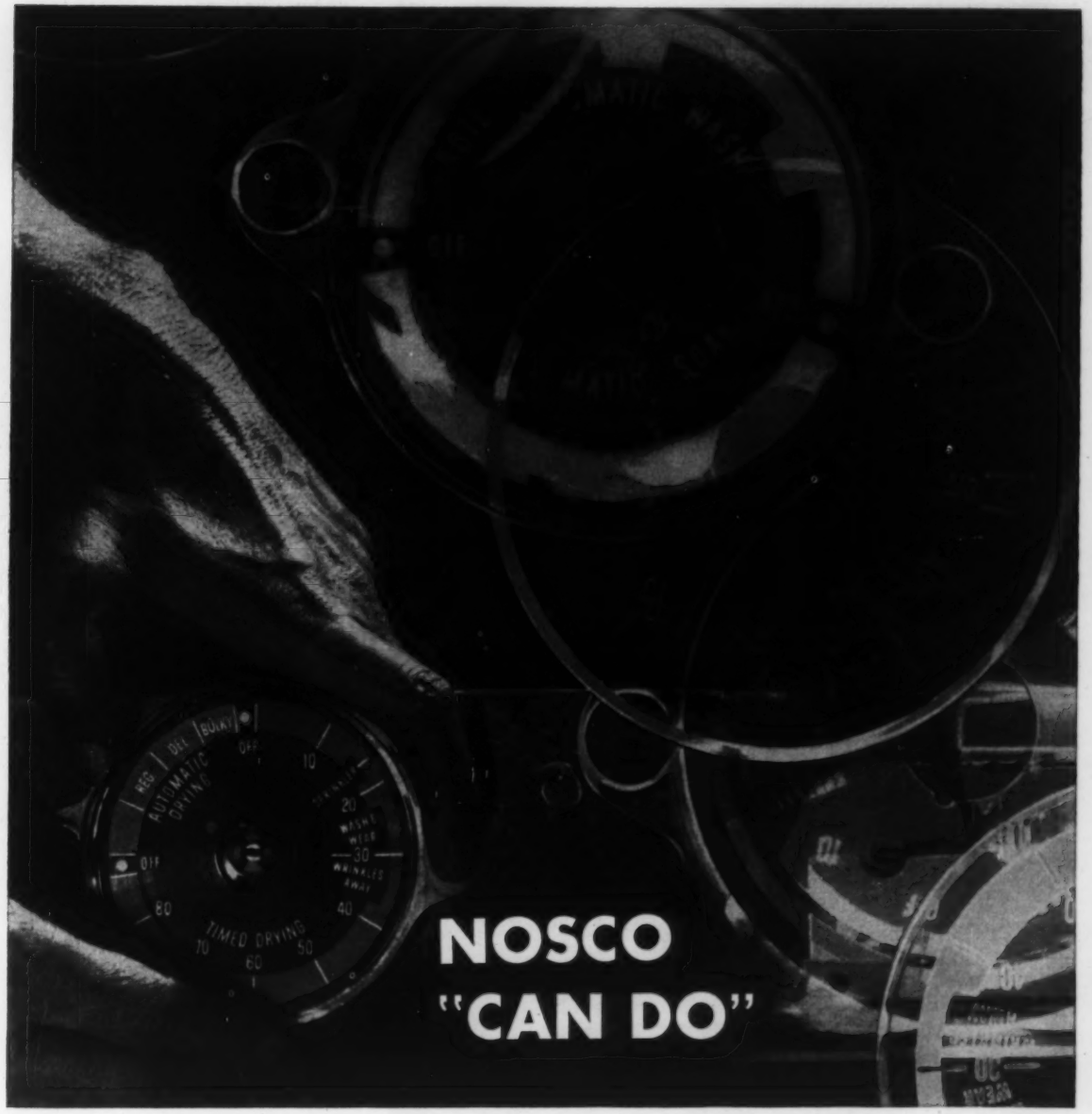
GET THE WHOLE STORY . . . WRITE TODAY

Eriez Mfg. Co., 131-RA Magnet Dr., Erie, Pa.

ERIEZ

Circle 491 on Page 19



Redesigns decorated plastic dial . . . steps up production rate 30%

Those hands belong to a busy appliance manufacturer. That dial he's attaching to the backsplasher may be small, but it once presented a man-sized production problem! That's when he came to Nosco and said "These specs on our new decorated acrylic dials are tough. They involve a complex, cup-shaped section with remote lettering. But we still want costs kept low. Can do?"

Nosco said "Can do—better and cheaper. Let us redesign each complex dial into two pieces that are easy to mold and easy to assemble. We'll hot stamp two colors at a time. And then, with this new design we can spray paint and wipe automatically. This way, costs are cut, production increased, and quality kept high."

The result: 2500 completed washer or dryer dials per shift—*30% more production* at no increase in cost! That's what Nosco "Can do" did recently for one happy manufacturer.

And Nosco "Can do" for you, too. We like tough injection molding and decorating projects. Let us show you how we can produce your plastic parts in volume, and perhaps cut costs by redesign. For more information call or write.

NP-59-01

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for increased production . . .
minimum down-time . . .
lower costs . . . specify

AIR and HYDRAULIC CYLINDERS

SERIES A

Rated 200 psi air and up to 500 psi oil or water, 23 mounting types. Corrosion-resistant, precision-honed, hi-tensile brass tube.

SERIES H

Rated 2,000 psi hydraulic. Complete range of mounting types. Precision-honed seamless steel tube.

- floating cushions—uniform cushioning—long life—fully adjustable
- easily removed cartridge-type rod seals with integral rod wiper
- choice of rod sizes for all applications—rods heat-treated and hard chrome plated for resistance to nicking and scoring
- steel heads and end plates for strength and positive alignment
- all ferrous parts rust-proofed

Before you buy any cylinder, consider the quality design and construction features of S-P air and hydraulic cylinders—features that will assure dependable performance . . . long service life . . . minimum down-time . . . lowest end cost.

What's your cylinder problem? We'd like to help you solve it—a phone call will bring our representative on the double. Prompt deliveries, too. The S-P Manufacturing Corporation, 30201 Aurora Road, Solon, Ohio.

for speed and performance

Representatives in principal cities. Phone or write for Catalogs No. 1108 (Series A) and No. 104A (Series H).

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HELPFUL LITERATURE

Knitted Metal Mesh

To familiarize designers with knitted wire mesh as an industrial component, periodicals covering various uses of this product will be issued. A few popular applications are enumerated in the first of these bulletins. 2 pages. Metal Textile Corp., 647 E. First Ave., Roselle, N. J. D

Circle 632 on Page 19

Ground Flat Stock

Plain oil hardening, Ready Mark oil and air hardening, and Thrift Stock low carbon ground flat stock are priced and listed in Bulletin M80. Properties of various types are cited, and available stock sizes are listed. 16 pages. Brown & Sharpe Mfg. Co., Industrial Products Div., Providence 1, R. I. B

Circle 633 on Page 19

Cast Steel Valves

Latest data on Kerotest cast steel gate, globe, angle, and swing check valves for refinery, industrial, and marine use are provided in Catalog KS1-M. Parts ordering information, trim material, recommended services, and a figure-number index are highlights. 20 pages. Kerotest Mfg. Co., 2525 Liberty Ave., Pittsburgh 22, Pa. F

Circle 634 on Page 19

Miniature Coaxial Cables

Both military and commercial-specification types of miniature coaxial cables are tabulated as to conductors and color-coded jackets in catalog. Temperature rating data, minimum tensile strength, and elongation standards are listed. 4 pages. Rex Corp., Aircraft & Electronics Div., West Acton, Mass. B

Circle 635 on Page 19

High-Copper Alloy

"Phosnic Bronze" is the title of a technical bulletin that describes this high-copper alloy which combines strength and electrical and thermal conductivity to a high degree. All properties and available forms of this material are tabulated. 8 pages. Chase Brass & Copper Co., Waterbury 20, Conn. B

Circle 636 on Page 19

Variable Speed Belts

Developed for use in all makes of variable speed drive units, VS Belts covered by Catalog V-173-B are listed alphabetically by make and model of drive. Interchange Guide compares them with other makes of belts. Included are numerical listings and list prices. 12 pages. Browning Mfg. Co., Maysville, Ky. G

Circle 637 on Page 19

Aluminum Mill Products

Specifications for hundreds of alloys and forms of aluminum are given in illustrated bulletin "Mill Products." Metal's advantages, 18 pages of alloy and temper designations, fatigue and shearing strengths, fabricating and finishing techniques, and other data are included. 18 pages. Request on company letterhead from Reynolds Metals Co., Box 2346, Richmond, Va. C

Circle 493 on Page 19

DO YOU HAVE THESE TWO REFERENCE AIDS?

Two of the most important books ever written for men concerned with producibility, offer practical techniques for designing for low-cost production. In effect, these two useable encyclopedias put production know-how into the hands of product development engineers.

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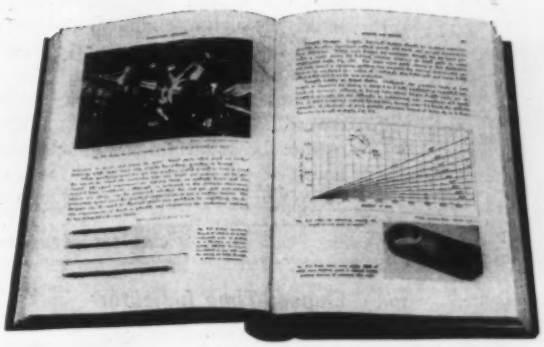

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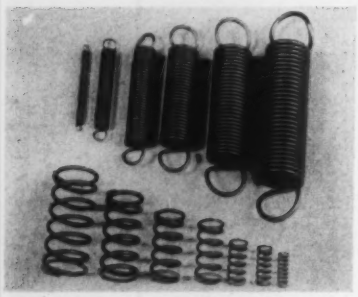
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Standardized Springs

in compression and extension types

Select-A-Spring system provides about 500 separate sizes of compression and extension springs. Compression springs have squared and ground ends, and extension units have regular loops. Other ends and loops are optional. All sizes meet industry and military standards, and are available in either



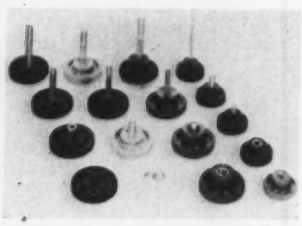
music wire or stainless-steel wire, certified to military and aircraft specifications. Compression - spring sizes range from ½ to 1½ in. long, and ⅛ to ¾ in. OD, with approximate load ratings from 1 to 20 lb. Extension-spring sizes are from 1 to 5 in. long, and ⅛ to ¾ in. OD, with maximum load capacities of about 20 lb. **Wallace Barnes Div., Associated Spring Corp.**, Bristol, Conn. B

Circle 638 on Page 19

Handwheels

plastic units are available in many varieties

Applications for new plastic handwheels include clamping wheels, adjusting knobs, and valve handles. Three of the knurled wheels have 1⅞-in. diam and are made from same basic mold, but variety of insert plugs and stripper pins permits many variations. Fourth wheel re-



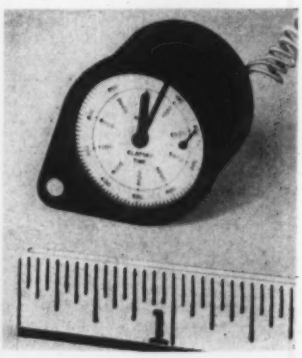
tains same shape but has diameter of 1⅜ in. Black phenolic is standard, but wheels are available in many phenolic and urea colors and can be produced with special characteristics such as chemical and heat resistance, extra strength, electrical insulation, and low friction. Each type of wheel is available with tapped inserts, threaded studs, reamed brass bushings and setscrew holes, or plain cored holes. **Dimco-Gray Co.**, 207 E. Sixth St., Dayton 2, Ohio. G

Circle 639 on Page 19

Elapsed-Time Indicator

subminiature unit has diam of less than 1 in.

SM-1 elapsed-time indicator operates from 400-cycle source at operating voltages to specification. It has nominal diam and length dimensions of less than 1 in., weighs only 1.25 oz, and has power consumption of 1½ w. Unit uses a subminiature, rugged, single-phase



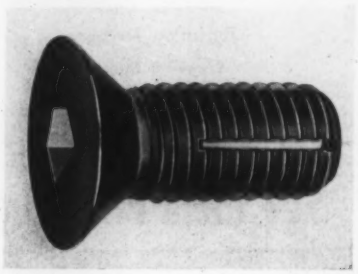
synchronous motor. Accuracy of running time summation is excellent for all normal equipment maintenance records and reliability studies. Indicator is designed to meet general requirements of MIL-I-7793B. **Hepta Electronics Inc.**, 2635 Louisiana Ave., Minneapolis 26, Minn. J

Circle 640 on Page 19

Self-Locking Screw

for temperatures to 1200 F

Hot-Lok screw incorporates an all-metal rolled tubular insert which is compressed by torque action. Resiliency of metallic tube causes re-forming of insert, producing locking effect on screw. Designed for use in supersonic applications at temperatures to 1200 F, unit has high reusability, is vibration resistant, and eliminates use of lock



washers and safety wire. Self-locking unit is available in No. 2 sizes and up, with minimum thread length of ¼ in., for aircraft and commercial applications. **Long-Lok Corp.**, 2601 Colorado Ave., Santa Monica, Calif. L

Circle 641 on Page 19

Power Transfer Units

right-angle models are rated ¼ to 2 hp

Right-angle power transfer line includes 17 new models equipped with nonmagnetic, stainless-steel shafts and double-sealed, hardened,

Truarc Retaining Rings, the engineered fastening method for reducing material, machining and assembly costs

function		for axial assembly				for taking up end-play					
						axial assembly				radial assembly	
nomenclature		basic		inverted		bowed		beveled		prong-lock®	bowed e-ring
series no.		5000	5100	5008	5108	5001	5101	5002	5102	5139	5131
application		Internal for Housing Bores	External for Shafts	Internal for Housing Bores	External for Shafts	Internal for Housing Bores	External for Shafts	Internal for Housing Bores	External for Shafts	External for Shafts	External for Shafts
range	in.	.250-10.0	.125-10.0	.750-4.0	.500-4.0	.250-1.456	.188-1.438	1.0-10.0	1.0-10.0	.094-.438	.110-1.375
	mm.	6.4-253.8	3.2-253.8	19.0-101.5	12.7-101.5	6.4-37.0	4.8-36.5	25.4-253.8	25.4-253.8	2.4-11.1	2.8-35.0

function		for radial assembly				self-locking types					
nomenclature		crescent®	e-ring	reinforced e-ring	interlocking	circular self-locking			triangular self-locking	triangular nut	grip-ring
series no.		5103	5133	5144	5107	5005	5115	5105	5305	5300	5555
application		External for Shafts	External for Shafts	External for Shafts	External for Shafts	Internal for Housing Bores	External for Shafts	External for Shafts	External for Shafts	With Threaded Screw	External for Shafts
range	in.	.125-2.0	.040-1.375	.094-.438	.469-3.375	.312-2.0	.094-1.0	.094-1.0	.062-.437	•	.077-.755
	mm.	3.2-51.0	1.0-35.0	2.4-11.1	11.9-85.7	7.9-50.8	2.4-25.4	2.4-25.4	1.55-11.1	•	•

GENERAL DESIGN PRINCIPLE: Tapered construction permits rings to maintain constant circularity and groove pressure.

Series 5000 and 5100: Basic types for axial installation. Rings provide optimum groove strength.

Series 5008 and 5108: Best clearances. Accommodate parts having large corner radii or chamfers.

Series 5103: Best clearances. Secure against moderate impact, vibration.

Series 5133: Provides high coupling shoulders; accommodates wide groove tolerances. Easy servicing.

Series 5144: Reinforced E-ring. Five times more gripping strength, 50% higher RPM limits than standard E-rings.

Series 5107: High impact resistance; high coupling shoulders. Accommodates extremely high rotation and relative parts rotation.

Series 5001 and 5101: Resilient end-play take-up. Accommodate wide tolerances. Recommended for pre-loading bearings.

Series 5002 and 5102: Rigidly locked end-play take-up. Recommended for locking one race of parallel bearing assemblies.

Series 5139: Rigidly locked into position by protruding locking tabs. Provides high resilient end-play take-up with sliding tabs for uniform flexure. Cannot be forced from groove without destroying ring. Accommodates relative parts rotation. Equally effective with round, square, rectangular or hex shafts.

Series 5131: Provides high take-up. Recommended where clearances are a major problem.

Series 5005, 5115, 5105 and 5305: Prongs dig into shaft, locking rings against movement in one direction.

Series 5300: Spring tension locks parts assembled with threaded screws.

Series 5555: Self-locking against movement in either direction by spring tension. Since no groove is required, ring is adjustable to any position on shaft.

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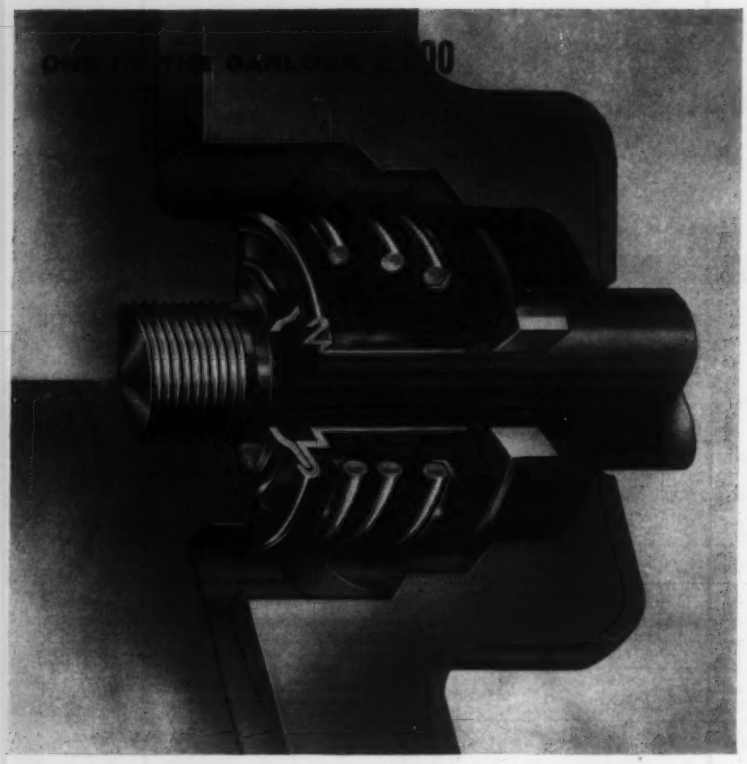
Waldes Truarc Retaining Rings are modern fasteners that solve a wide variety of design and production problems. Send for your new 24-page Catalog RR 10-58. D-4

WALDES TRUARC® RETAINING RINGS

Waldes Kohinoor Inc., Long Island City 1, N. Y.



Low-cost, leak-proof seal for pumps, major appliances

Garlock H Mechanical Seals are widely specified for home water and oil pumps, reduction units, mass-produced appliances like washing machines, and other consumer products. Use them on 5/8", 3/4", and 1" shafts and retain same top advantages of more expensive seals.

Positive, no-leak operation. Sealing surface of the ceramic stationary seat and the carbon sealing ring are lapped for precision contact—this assures a perfect seal.

Simple installation. You merely slide the self-contained rotary unit onto the lubricated shaft. Then, with oil or water, lubricate the outside diameter of the vibration ring and push into counterbore.

You can apply Garlock H Mechanical Seals wherever operating conditions do not exceed 212°F temperature, 75 psi pressure, and 1000 fpm shaft speed. For more severe applications, consider PK Mechanical Seals. Both are part of the Garlock 2,000 . . . two thousand different types of gaskets, packings, and seals for every need. Find out more by contacting your local Garlock representative, or write for Catalog AD-161.

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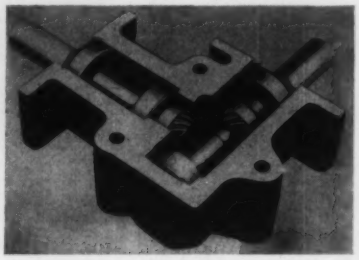


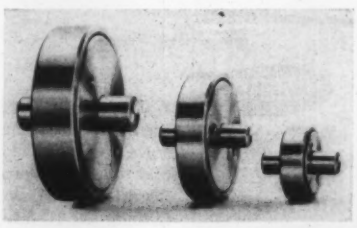
and ground ball bearings. Standardization on hardened steel, spiral gears produces increased life, ability to handle higher load capacities, and quieter operation. Features include: Choice of two and three shaft extensions; light, compact, enclosed 356 aluminum-alloy housing designed for maximum strength and heat dissipation; choice of four or five mounting positions. Units can be furnished either in two or three-way designs, and each type has optional 1:1 or 2:1 ratios. Ratings range from 1/4 through 2 hp. **Crown Gear Co.**, 320 Park Ave., Worcester 10, Mass. B

Circle 642 on Page 19

Rotary Positioning Controls

miniature units hold loads up to 200 lb-in.

Designed for applications such as no-back devices, valve and potentiometer positioners, dial controls, clutches, and couplings, miniature controls feature zero backlash and low breakaway torques. They have been tested for rotating speeds to 3800 rpm. Loads ranging up to 200 lb-in. can be held positively and accurately in an infinite number of positions for clockwise or counterclockwise rotation. Diameters of the units are 3/4 and 1 1/4 in. with depth of 5/16 in., and 1 3/4 in. diam with depth of 5/8 in. The 3/4-in. model is rated for loads to 50 oz-in., 1 1/4-in. unit for loads to 50 lb-in., and 1 3/4-in. model for loads to 200 lb-in. Controls are supplied for flange or setscrew



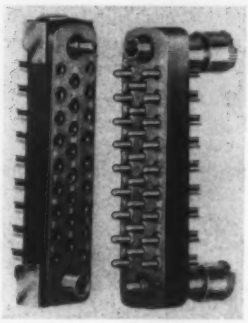
mounting with through or interrupted shafts. Shafts of 1/8, 3/16, 1/4, 5/16, and 1/2 in. are available, depending upon model. Controls can be manual, motor, hydraulic, pneumatic, or solenoid actuated. **Reid Controls Div., Reid Metal Products Inc.**, 2021 N. Lincoln St., Burbank, Calif. L

Circle 643 on Page 19

Subminiature Connectors

incorporate stainless-steel reinforcing retainers

Precision connectors are suitable for critical environmental conditions. Stainless-steel reinforcing retainer is provided under each screwlocking element to remove all torque stresses from molded bodies, avoiding breakage. Positive re-entrance of male



pins is assured each time by a flanged-guide female contact. Self-alignment action is also assisted by wider countersink on upper end of contact. Connectors are available in total contacts of 7, 11, 14, 20, 26, and 32, or custom configurations are furnished to meet specific requirements. **U. S. Components Inc.**, 454 E. 148th St., New York 55, N. Y. D

Circle 644 on Page 19

Hex Nuts

are reduced in size and weight

Flyweight series hex nuts provide weight saving of up to 75 per cent over AN types and space saving of 35 per cent over standard hexagon nuts. In spite of reduced size and weight, there is actually more cubic content of metal supporting threads than on former sheet-metal NAS679 types, permitting higher wrench torques and greater fatigue life for

EMCOR®* Pre-engineered cabinets give erector-set versatility to industrial needs

From a single unit to a complete control center . . . EMCOR Standard Cabinets answer your housing problem. Shown above, closed circuit TV in Southern Railway System's Modern Yards "pick" car numbers from inbound trains.

Central nerve center of the new Diana Stores Corporation, New York City, automation warehouse system is a single EMCOR Cabinet. The operator dials incoming cartons into the electronic control system which directs the merchandise to its proper destination on the building's third, fourth or fifth floor. Standard stock frames of the EMCOR MODULAR ENCLOSURE SYSTEM provide design flexibility . . . provision for expansion or exchange of equipment, and custom features in each pre-engineered cabinet. Advanced engineering know-how meets today's electronic packaging demands with years ahead planning. Answer your enclosure problem easily . . . from the complete EMCOR line of pre-engineered cabinets and components.

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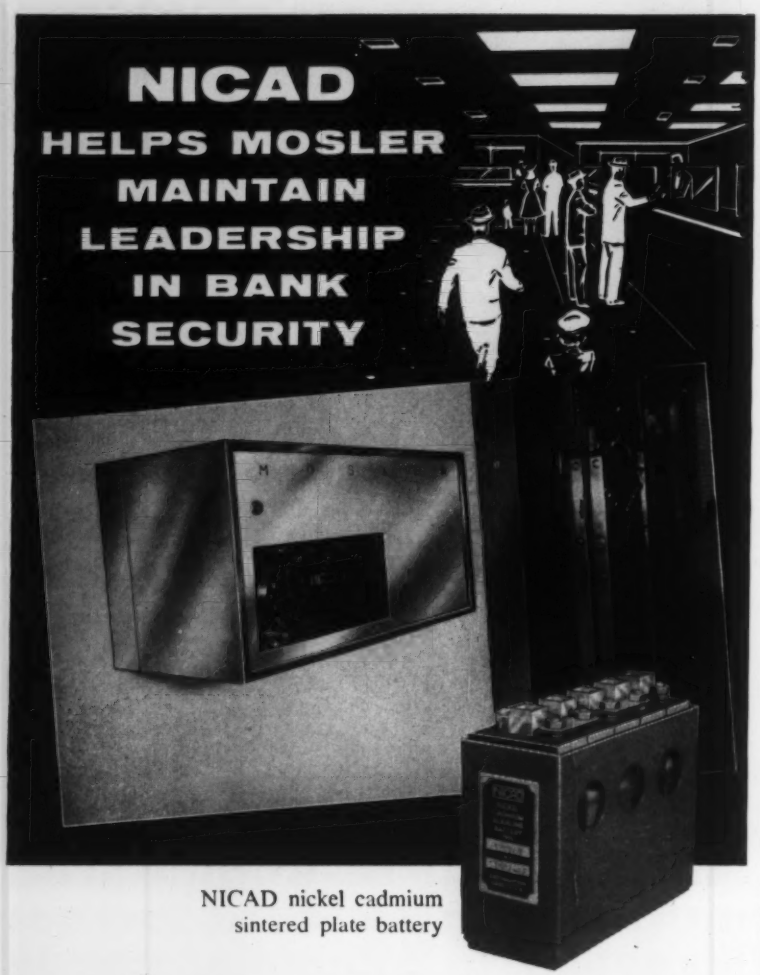
Circle 497 on Page 19



NICAD nickel cadmium sintered plate battery

With a reputation for providing top security, The Mosler Safe Company must be certain that its Century Bank Alarm system will perform reliably *under any conditions.*

A NICAD nickel cadmium battery makes such performance a certainty. Should the main power source fail, the NICAD battery provides vital stand by power.

NICAD sintered plate batteries were chosen by Mosler on the basis of proved dependability and long-term service—a combination through which NICAD offers long-range economy. Additionally, NICAD offers cycle life which far exceeds that of any other battery . . . peak operational efficiency under severe conditions . . . low internal resistance that creates high discharge rates . . . capacity range from ½ to over 150 ampere hours.

For more information on the adaptability of NICAD batteries to signal alarm systems, air and space craft, microwave and telemetering devices, and similar equipment, request Bulletins 501 and 501A from NICAD Division, Gould-National Batteries, Inc., Easthampton, Mass.

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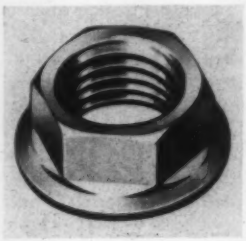


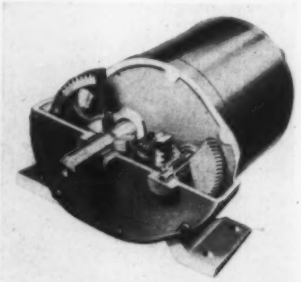
thread. Reduction by two in hexagon size permits use of smaller wrenches and narrower bolting flanges. Type T99S low beam is furnished in chrome-moly vanadium alloy steel, with nickel-cadmium diffused plating for 160,000 psi at 550 F and 90,000 psi at 900 F. Type T99C is available for low magnetic permeability requirements, allowing higher stress levels at 900 F than with alloy steel. It is also furnished in brass for high electrical conductivity and where low-strength, 60,000-psi brass screws are being used. T99C is recommended where moderately high initial torque of steel lock nuts is too severe for screw and high reusability is needed. **Boots Aircraft Nut Corp.,** 536 Newton Turnpike, Norwalk, Conn. B

Circle 645 on Page 19

Gear Motor

provides speeds of 30, 60, or 120 rpm

VW-10 low-cost gear motor uses an integrally mounted, ¼-hp, split-phase motor. It provides speeds of 30, 60, or 120 rpm with developed torque of up to 433 lb-in. Unit is recommended for intermittent or continuous duty in such applications as rotating or revolving displays, small conveyors, and other equipment requiring low-speed motive power. Electrically reversible unit has motor mounted directly to cast-aluminum gear housing, elim-



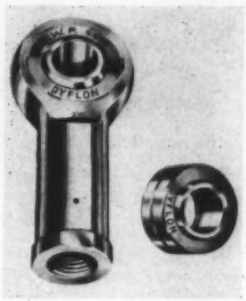
inating alignment problems. Permanently lubricated, gear motor is designed for 115 v ac, 50 C rise above ambient. **Von Weise Gear Co.**, 9353 Watson Industrial Park, St. Louis 19, Mo. I

Circle 646 on Page 19

Self-Lubricating Bearings

have high load safety factor

Monoball Dyflon self-aligning plain bearings require no maintenance or service. They are recommended for applications requiring low coefficient of friction, long service life without lubrication, and high dynamic load-carrying capacity. Monoball design provides high load-safety factor. Bearings are avail-



able in a variety of plain and rod-end types in bore sizes from 3/16 to 6 in. diam. Rod-end types have either externally or internally threaded shanks. Materials used include chrome-alloy steel, stainless steel, and plastics. **Southwest Products Co.**, 1705 S. Mountain Ave., Monrovia, Calif. L

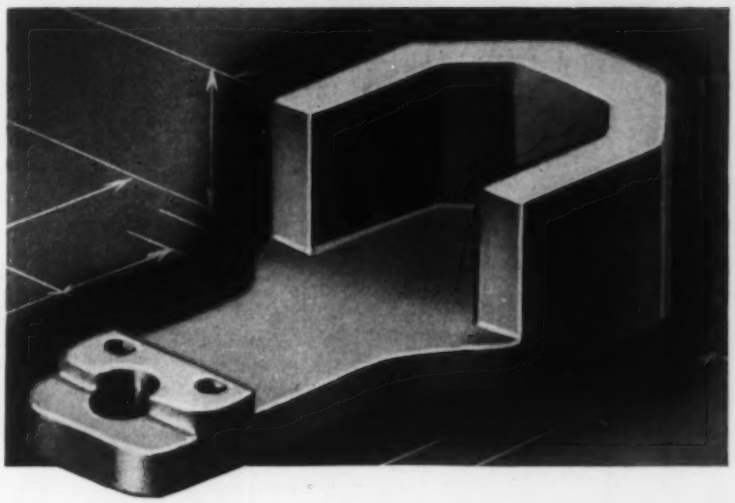
Circle 647 on Page 19

Pushbutton Switch

lighted unit has four lamps

Quadlite design incorporates single-pole, double-throw subminiature switch, switch actuator, and four lamps in one unit only 7/8 in. square. Designed especially for matrix applications, unit features mechanical interlocking for master resetting or mutual cancellation. It mounts with or without barriers, or in matrix on 7/8-in. centers, both directions. All four lamps and color-filter assembly are easily removed from front of panel. Color filters are

economy...speed... in volume production of complex parts...



The photograph shows a bearing support plate for a new line of power tools manufactured and marketed by a large and very capable organization.

The complex nature of the part is apparent at a glance and the cost of machining such a part is evident to the eye of engineer and designer.

It is on parts of this nature that powder metallurgy offers its greatest advantages and its greatest opportunities for the future.

Such parts require most careful designing of the tooling from which they are produced, plus painstaking and tedious effort until the part can finally be produced in volume.

A manufacturer with such requirements naturally turns to Bunting where the necessary persistence until success is achieved is one of the Company's recognized characteristics.

For the unusual, as well as the usual, in bearings, bushings, bars and special parts of cast bronze or sintered metals, see Bunting first.

BUNTING SALES ENGINEERS in the field and a fully staffed Product Engineering Department are at your command without cost or obligation for research or aiding in specification of bearings or parts made of cast bronze or sintered metals for special or unusual applications.

...ask or write for your copy of...

Bunting's "Engineering Handbook on Powder Metallurgy" and Catalog No. 58 listing 2227 sizes of completely finished cast bronze and sintered oil-filled bronze bearings available from stock.

The Bunting Brass and Bronze Company
Toledo 1, Ohio EVergreen 2-3451

Bunting®

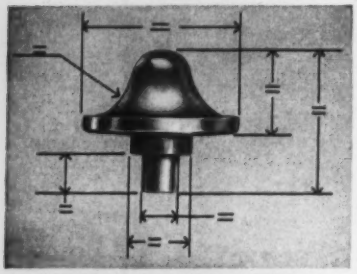
Branches in Principal Cities

BEARINGS, BUSHINGS, BARS AND SPECIAL PARTS OF CAST BRONZE OR SINTERED METALS.

Circle 499 on Page 19

IT PAYS TO HAVE GOOD CONNECTIONS
HUBBELL
Manufacturers of Cold Headed Fasteners Since 1888

OVER 10 TIMES THE RATE
AT 50% SAVING
IN RAW MATERIAL

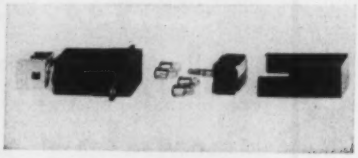


Another example of how Hubbell Cold Heading produces Better Parts at Faster Speeds, at Lower Cost

THE PART:
Click Button
THE MATERIAL:
Brass
THE METHOD:
Hubbell cold heading in place of screw machining.
THE RESULT:
This brass click button was machined previously from bar stock, involving several different operations that removed nearly 50% of the total weight of the original stock . . . a wasteful, time-consuming, costly process.
Hubbell now produces essentially the same part at tremendous savings in time and material cost.
a. Production is increased from the original rate of 5.5 pcs. p.m. to cold heading rate of 60 pcs. p.m.
b. Labor, overhead and material cost has been reduced 36%.
c. The finished part is stronger, more accurate, with greater uniformity.
Hubbell Cold Heading may provide equally dramatic results for you. Whether it is presently cold headed or not, send blueprint of part or sample for analysis and estimate.

HARVEY HUBBELL, Inc. *Machine Screw Dept.*
Bridgeport 2, Connecticut
Kindly estimate on the enclosed sample (blueprint) Quantity _____
Name _____
Title _____
Company _____
Address _____

Circle 500 on Page 19



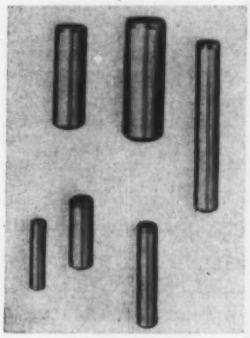
available in combinations of any of six standard colors, plus white. Switch is available with a variety of mounting methods and terminations to fit any application. **Switch Div., Electrosnap Corp.**, 4218 W. Lake St., Chicago 24, Ill. J

Circle 648 on Page 19

Dowel Pins

of heat-treated alloy steel

Blue Devil dowel pins have surface hardness of Rockwell C 60 to 64, with finish of 8 microinches rms maximum to assure accurate positioning to close tolerances. Standard pins are ground 0.0002 in. over listed diameter for press fit between mating parts. Tolerances are ±0.0001 in. Pins are available in



heat-treated alloy steel in sizes from 1/8 to 1 in. **Safety Socket Screw Co.**, 6501 N. Avondale Ave., Chicago 31, Ill. J

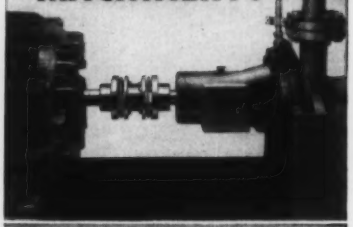
Circle 649 on Page 19

Silicon Diode

miniature unit is light-sensitive

No. 1N2175 subminiature, light-sensing, photoduodiode allows current flow when either junction is exposed to light, but effectively shuts current off in darkness. Sensitivity of the device, plus subminiature size, makes it suitable for applications such as reading data from punched tape and card systems. Single-ended glass case measures

THOMAS
FLEXIBLE COUPLINGS
Protect your PUMPS and other Indispensable MACHINERY!



NO LUBRICATION
NO MAINTENANCE
NO WEARING PARTS

Future maintenance costs and shutdowns are eliminated when you install Thomas Flexible Couplings. These all-metal couplings are open for inspection while running.
They will protect your equipment and extend the life of your machines.
Properly installed and operated within rated conditions, Thomas Flexible Couplings should last a lifetime.

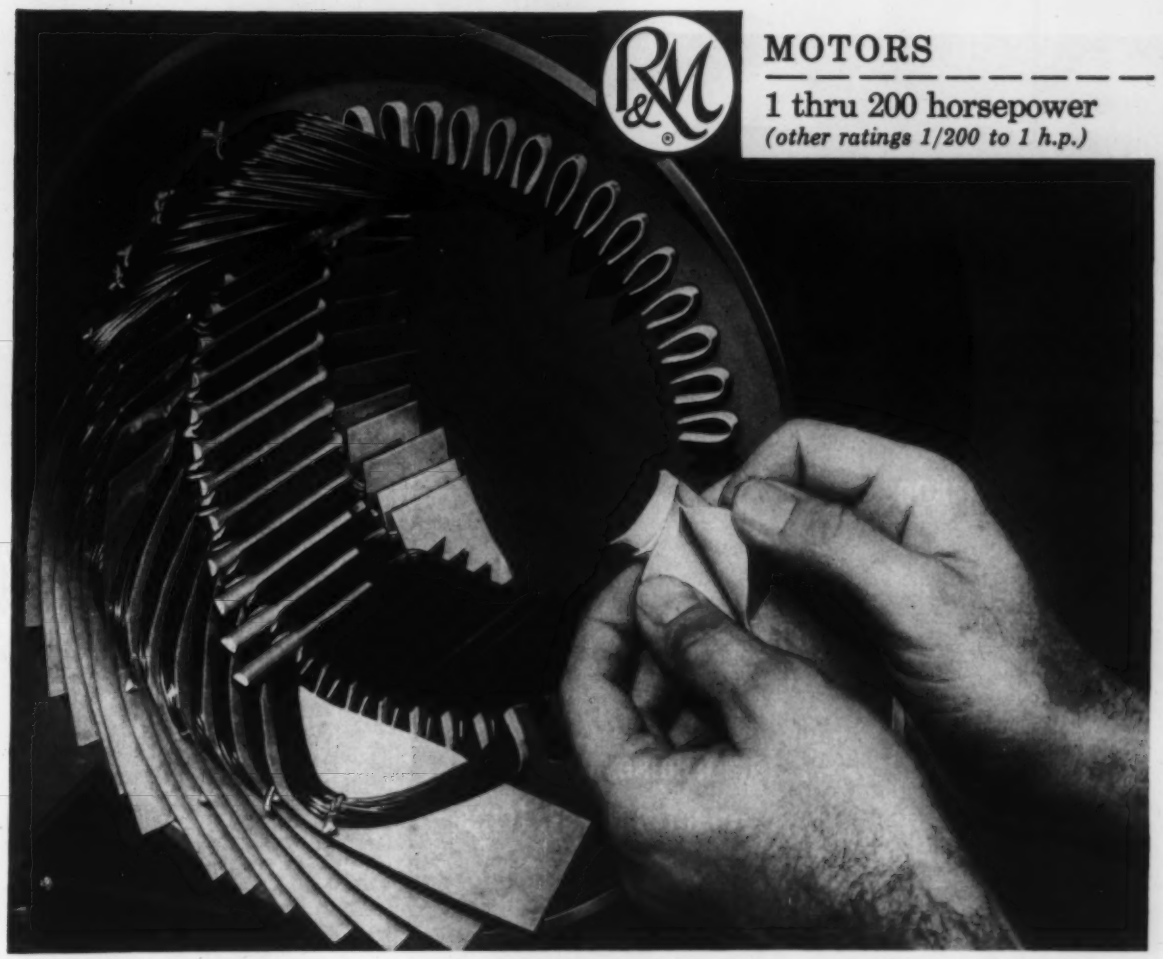
UNDER LOAD and MISALIGNMENT ONLY THOMAS FLEXIBLE COUPLINGS OFFER ALL THESE ADVANTAGES:

- Freedom from Backlash
- Torsional Rigidity
- Free End Float
- Smooth Continuous Drive with Constant Rotational Velocity
- Visual Inspection While in Operation
- Original Balance for Life
- No Lubrication
- No Wearing Parts
- No Maintenance

Write for Engineering Catalog

THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA, U.S.A.

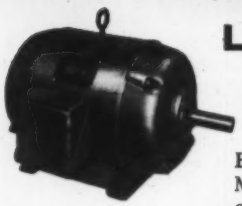
Circle 501 on Page 19



MOTORS

1 thru 200 horsepower

(other ratings 1/200 to 1 h.p.)

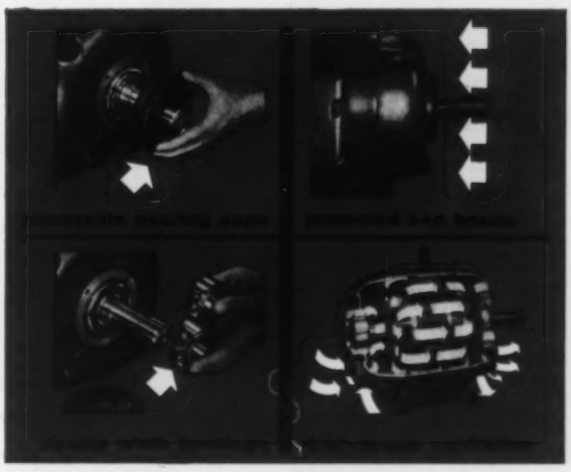


Locked-In, Laminated Insulation

Insures Longer Life for your R&M Motor!

Each slot-cell in your ROBBINS & MYERS motor grips a triple layer of insulation around the windings. Installing these insulation "sandwiches" is a time-consuming job but it pays off in long motor life. Mylar* laminated to rag paper is first inserted. Reinforced edges prevent slipping and scuffing. The dielectric qualities of Mylar* (8 times that of conventional insulation) combined with its resistance to tearing and aging affords permanent protection; the rag paper backing acts as a cushion against abrasion and punctures. A second layer of insulation is inserted to eliminate the danger of weak spots. The wire coil, coated with triple resin insulation, is inserted and a third layer of insulation is placed over it. Insulation is placed between the coil ends, wedges are inserted to hold the coil firmly in place and the stator is twice dipped in special insulating varnish and baked after each dip, thus forming an armor-like coating. Coil ends are coated with a moisture-proof sealer. This is insulation you can trust, yet it's yours at standard prices! For more details write for Bulletin 520 MD

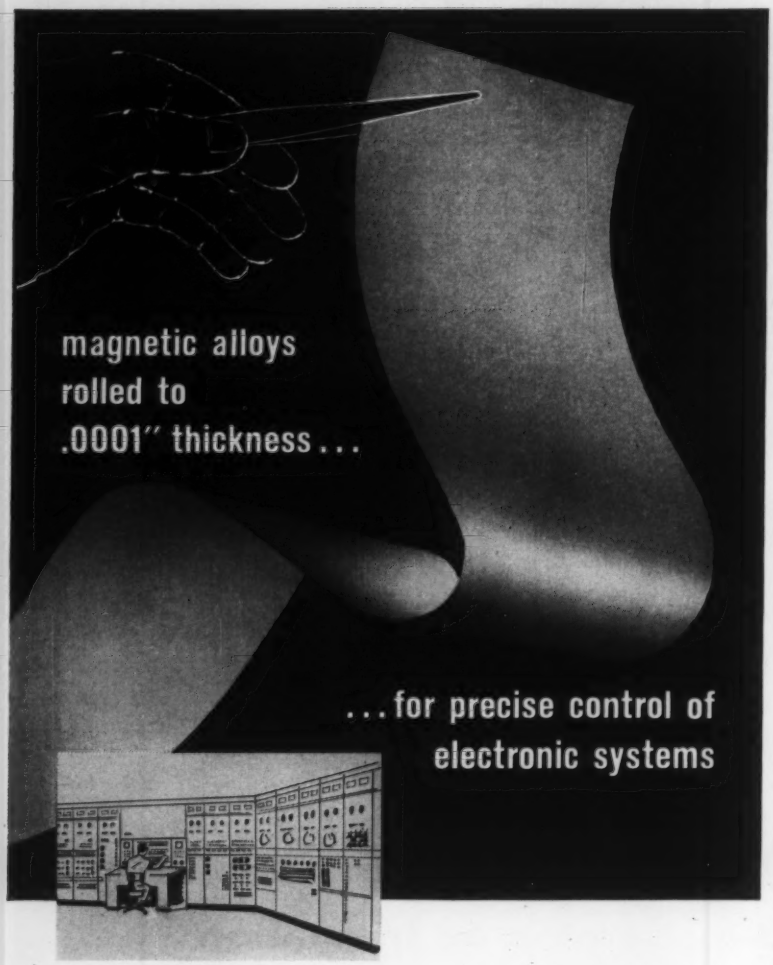
**DuPont registered trademark*



ROBBINS & MYERS, INC.

motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

SPRINGFIELD, OHIO · BRANTFORD, ONTARIO

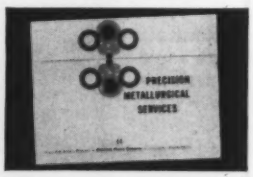


Now you can obtain high magnetic permeability alloys such as 4-79 Moly Permalloy, Alfenol, and HyMu "80" in cold rolled strip and foil in **production** quantities! The unique and newly expanded facilities of Precision Metals Division are geared to produce ultra-thin metal strip and foil in any quantity and in virtually any alloy.

Precision Metals strip and foil for development and production offer these special advantages:

uniform magnetic properties
thicknesses from .010" to .0001"
dimensional uniformity
extremely close tolerances
excellent surface characteristics

For specific requirements, Precision Metals can also furnish custom alloys to your own specification in the form you need. Write today for fully illustrated facilities booklet, MD-4.



HAMILTON
WATCH COMPANY / **Precision Metals Division**
Lancaster, Pennsylvania

Circle 504 on Page 19

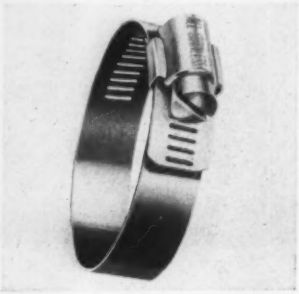
only 0.5 in. x 0.085 in. diam. Minute glass lens is located at end opposite leads. Unit passes up to 1200 ma when exposed to 1200 ft-c of light. In darkness it will pass less than 0.5 ma. The double-diode unit operates equally well on either ac or dc. It is derated to 125 C with minimum operating temperature of −55 C. **Semiconductor-Components Div., Texas Instruments Inc.**, P. O. Box 312, Dallas, Tex. P

Circle 650 on Page 19

Worm-Drive Clamp

connects lengths of hose or plastic pipe

Hy-Gear worm-drive clamp is a noncollared version made in a full range of sizes. It is designed to connect lengths of rubber hose and plastic pipe. Clamp has holding



power and resistance to corrosion equal to safety collared model. **Ideal Corp.**, 435 Liberty Ave., Brooklyn 7, N. Y. D

Circle 651 on Page 19

Gear Motor

fractional-horsepower unit has 10:1 to 60:1 ratios

Fractional-horsepower gear motor, available in ratios from 10:1 to 60:1, consists of a gear-reduction unit in combination with either induction or universal motor. As a universal ac/dc or shunt motor, unit has ratings of 1/70 to ¼ hp and torque output to 60 lb-in., depending on ratio used. As an induction unit, it is available in two and four-pole models from 1/70 to 1/15 hp with same range of torque ratings. Either manual or automatic overload protection can be supplied for all applications except low-voltage dc use. Brush-type motors

can be supplied with single speed, two speed, or adjustable-speed governors. **Howard Industries Inc.**, 1700 State St., Racine, Wis. K

Circle 652 on Page 19

Aluminum-Bronze Bars

are 12½ in. long and up to 8 in. OD

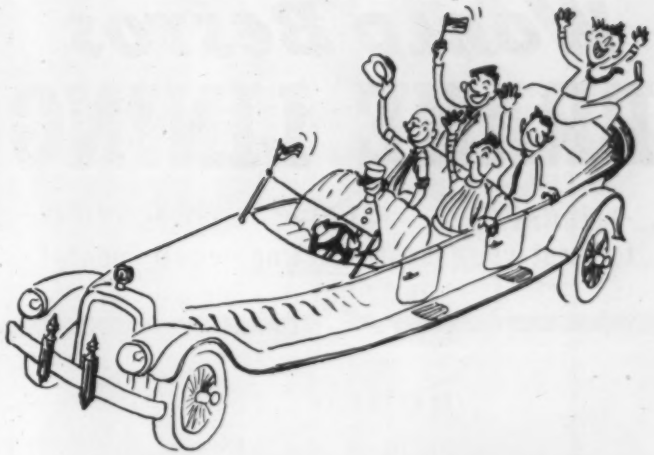
Applications for aluminum-bronze bars include gears, worms and worm wheels, valve seats and guides, hydraulic valve parts, plungers, pump rods, guide pin bushings, and special bearings. Bars offer excellent resistance to wear and fatigue. Uniform quality eliminates inclusions, porosity, and undersurface defects. Solid bars are supplied with extruded finish. Centrifugally cast cored bars are semifinish machined on ID and OD. Both types are available in standard 12½-in. lengths and in 97 sizes up to 8-in. OD. **Johnson Bronze Co.**, New Castle, Pa. G

Circle 653 on Page 19

Electrical Connector

for use at temperatures to 1200 F

Electrical connector is 300 series stainless steel with chemical bond to ceramic material completely free from boron. It operates in nuclear environments without deterioration. Impervious to thermal shocks of over 700 F, connector maintains electrical integrity and hermetic seal up



UNSUNG HEROES

We wish we could afford a newer automobile with an emblazoned banner for *each* of these gentlemen*, to tell the whole relay-using world of their accomplishments. For these are the souls who design that seldom-heralded product—the plebeian Sigma relay. Unlike more renowned Sigma engineers, they can never go home at night and say "Today I built a relay that will make history"; instead, their efforts will only keep someone's juke box, remote-controlled toy, electric blanket or burglar alarm working.

Here are five of their achievements that are about as experienced as relays can be; the "4", "5" and "41" have proved themselves since early WW II days, the others almost as long. Being old standbys also means they're for sale and deliverable in quantity.

* Perhaps you recognize the man on the spare tire as Mackinaw L. Mundane of April 1958 fame.

AC		DC
	Series 4	Rugged, lightweight general-purpose SPDT design with adjustable pull-on and drop-out. Standard sensitivity 20 or 50 mw., rated 2 amperes resistive for 100,000 operations.
Built-in rectifiers. Operation comparable to DC performance, except for coil overload capacity and speed.	Series 5	Dual coils, SPDT, sensitivities from 1 mw. to 2 watts. High stability and shock resistance. Available adjustments include precision DC, close differential, meter protection, break-delay, etc.
Shaded pole version, for 60 cycle positive ON-OFF operation only. Standard sensitivity 0.3 volt-ampere. Type 11F — 1 5/32" x 1 5/32" x 1" high, wt. 1 oz. max.	Series 11	Small, low cost ($1.50-2.45) SPDT relay. Ideal for remote control units for toys and TV sets, door openers, etc. Mechanical life 100,000,000 operations. Four mtg. styles, unenclosed only.
Shaded pole SPDT design. Sensitivity 0.06 to 0.40 volt-ampere, 60 cps (specials for 16-400 cps.) Long life; quiet, inexpensive. Ratings up to 5 amperes resistive.	Series 41	DC sensitivities 40 to 200 mw. Fast, bounce-free switching; useful for keying; speeds to 100 pps. Shock and constant acceleration up to 100 g will not cause damage.
DPDT version of Series 41, but with 0.30 and 0.50 volt-ampere standard sensitivities. Standard frequency 60 cps, specials 16-400 cps. Contacts rated 2 or 5 amperes. Economical of power.	Series 42	DPDT version of Series 41, but with 100 and 200 mw. standard sensitivities. Can serve as output relay of many electronic controls; often used where UL approval is required. Contacts rated 2 or 5 amperes.

Bulletins on any of these Series on request.

SIGMA

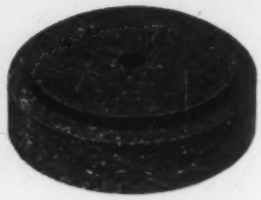
SIGMA INSTRUMENTS, INC.
89 Pearl St., So. Braintree 85, Mass.
AN AFFILIATE OF THE FISHER-PIERCE CO. (Since 1938)

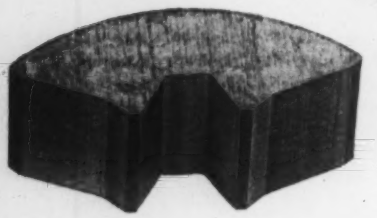
WORLD BESTOS BRAKE LINING

...any *shape*...any *size*...any *friction* to meet your most exacting requirements!

ROUND

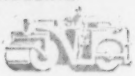
as for Race Cars





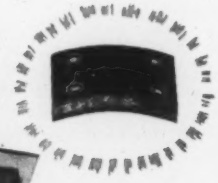
INTRICATE

as for Industrial Brakes



TINY

as for small Precision Assemblies



BIG

as for giant Forming Presses

● World Bestos is currently helping many manufacturers solve difficult braking problems with special friction formulas that assure dependable stopping power, non-fading performance and extra long life.

World Bestos offers extensive research and development facilities and more than 30 years' specialization in friction material manufacture. Modern, high-capacity plant assures on-schedule delivery.

● **Write for new Industrial Brake Folder . . . or let us know your specific requirements. Send prints and specifications if possible. Engineering assistance available.**

WORLD BESTOS NEW CASTLE INDIANA

DIVISION OF THE **Firestone** TIRE & RUBBER CO.

Industrial and Automotive Brake Blocks and Linings • Transmission Linings • Special Clutch Facings • Vibration Controls • Sheet Packing

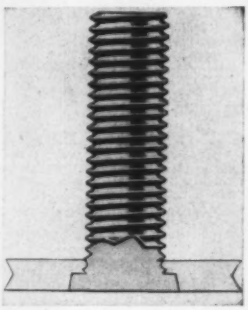
to 1200 F. Connector is available in popular configurations, including subminiature sizes. Pressed-metal keyway can be attached by spot welding over a distributed area and contact made secure. Keyway also serves as a spring, giving greater attaching force to connector and receptacle. **Technical Industries Corp.**, 389 N. Fair Oaks Ave., Pasadena, Calif. L

Circle 654 on Page 19

Self-Clinching Stud

for flush-head use in metal panels

Captive stud is designed for quick, easy, flush-head installation in panels of cold-rolled steel, brass, copper, aluminum alloys, and similar materials of thicknesses from 0.040 in. up. The self-clinching unit is dropped into punched or



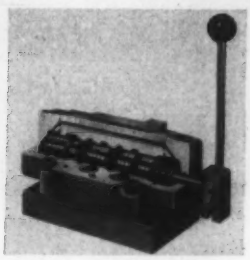
drilled holes and squeezed into place by use of standard pneumatic, hydraulic, or mechanical presses. Squeezing action embeds head projections of stud into panel. Displaced metal flows smoothly and evenly around back-tapered shank and annular groove, creating flush-head assembly and securely locking stud into panel with high torque and push-out resistance. Stud is available in steel and 305 stainless-steel types in thread sizes from No. 4-40 to 5/16-18, and in lengths from $\frac{1}{4}$ to $1\frac{1}{2}$ in. **Penn Engineering & Mfg. Co.**, Doylestown, Pa. E

Circle 655 on Page 19

Hydraulic Valve

for 3000-psi service in automated machinery

Manually controlled by a lever, Model 6100 valve is subplate mounted and is available in five actions. It is for 3000-psi service



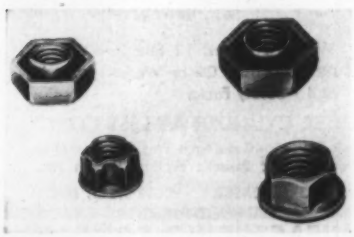
in manufacturing processes where machinery has been automated, and meets all JIC requirements. Valve has large, unrestricted passages to allow greater flow capacity. Piston has long sealing surfaces, and scalloped design of spool meters fluid to resist shock. Seven basic spool designs range in size from ¼ to 2 in. **Rivett Inc.**, Brighton 35, Boston, Mass. B

Circle 656 on Page 19

Self-Locking Nuts

have minimized hex body section

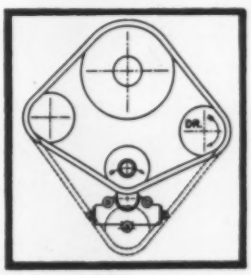
Type LH3334 high-strength lock nuts are over 40 per cent lighter than current NAS types. Minimized hex body section has a base ring to assure good thread-load distribution and to provide adequate bearing area for use with soft metals like aluminum. Lock nut offers wrenching dimensions two socket sizes smaller than equivalent NAS or AN nuts. Hex dimensions are fully compatible with standard wrenches, and low-height nut can be used to develop full strength of 160,000-psi bolts, including short thread NAS units. Nuts meet all applicable performance requirements of AN-N-10 and MIL-N-25027 (ASG). For temperatures to 550 F, they are of heat-treated carbon steel, cadmium plated with supplementary molybdenum disulfide dry-film lubricant. Identical configuration, LH3358, is provided for temperatures to 900 F, and is A286



AUTOMATIC DRIVE TENSIONER

Keep your drives operating *without slack* — at peak efficiency — with the Whitney Automatic Drive Tensioner. The Tensioner (patented) is a simple, easily-mounted unit which applies a steady and continuous take-up which reduces whipping and compensates for drive wear on chain, V-belt or flat belt drives. Simply install a sprocket, roller or sheave, which can rotate freely on the crank arm.

The Whitney Tensioner will pay dividends in longer drive life and increased efficiency. Available "off-the-shelf" from your local Whitney Chain distributor.



ADVANTAGES

- Positive action take-up, simple construction.
- Flat base, three bolt installation. Position or location easily changed.
- Continuous and adjustable spring pressure.
- Crank arm action can be clockwise or counterclockwise.

Write for complete specifications and installation data.

Whitney CHAIN COMPANY

405C Hamilton Street • Hartford 2, Connecticut

ROLLER CHAIN • CONVEYOR CHAIN • SPROCKETS • FLEXIBLE COUPLINGS • WHITNEY-TORMAG DRIVES

Circle 507 on Page 19

corrosion-resistant steel. Both series are furnished in sizes No. 4-40 through ⅜-24, and are available at present in 10-32 and ¼-28 sizes. **Elastic Stop Nut Corp. of America,** 2330 Vauxhall Rd., Union, N. J. D

Circle 657 on Page 19

Telemetering Battery

provides normal discharge voltages of 27 and 6.6 v

Silvercel battery has eighteen 15-amp-hr, high-rate, silver-zinc cells and five 10-amp-hr silver-zinc cells, providing normal discharge voltages of 27 and 6.6 v. Unit can be used in missiles, particularly for telemetering applications. Weighing 26 lb and measuring 6.75 in. high by 10.187 in. in diam, it meets such requirements as operation at altitudes to 200 miles and at temperatures from 0 to 125 F, shelf life of one year, and rechargeability of 10 cycles. Battery is pressurized and is furnished in a case of lightweight, corrosion-resistant magnesium alloy to withstand severe stress conditions.

Voltage is practically constant. Ampere-hour capacity, weight and size, and electrical energy can be varied to suit requirements. **Yardney Electric Corp.,** 40-50 Leonard St., New York 13, N. Y. D

Circle 658 on Page 19

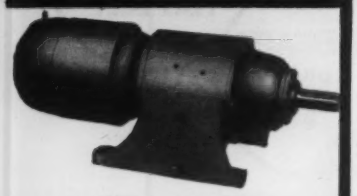
Keyboard Switch

has six independent poles

New keyboard switch is designed for light-action, keyboard-type installations where additional switching circuits are required. It is available in either push-on, push-off, or momentary types. Six independent poles are supplied in any combination of normally open or closed contacts. Switch has 1 to 2 lb operating pressure, ½-in. mount-

D.O.James
Established 1888

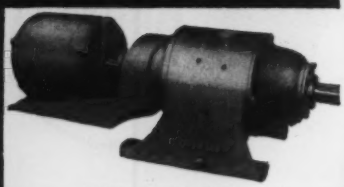
IN-LINE GEARMOTORS



TYPE "MG"

IN-LINE GEARMOTOR—Horizontal or Vertical Drive, 37 sizes, ratio 9.2:1 to 1200:1, 1 to 75 H.P.

IN-LINE MOTOREDUCERS



TYPE "MS"

IN-LINE MOTOREDUCER—Horizontal Drive, 37 sizes, ratio 9.2:1 to 1200:1, 1 to 75 H.P.

Since 1888 · MAKERS OF EVERY TYPE OF GEAR AND GEAR SPEED REDUCER

THESE In-Line D.O.James Gearmotors and Motoreducers are of the same construction and high quality as the individual Gear Speed Reducers which we have been producing for so many years.

They cover a very wide range of ratios, horsepowers, and are an ideal, compact, efficient unit for many power and space-saving installations.

D.O.JAMES
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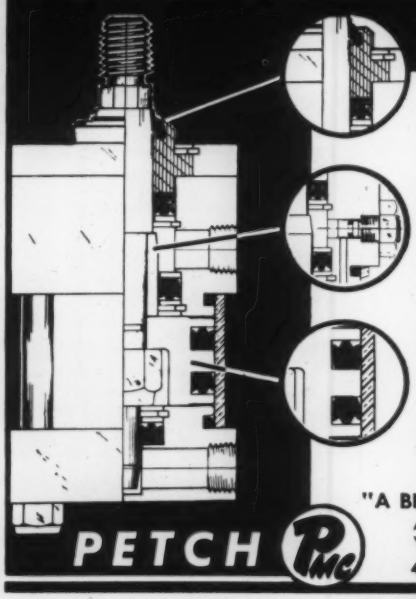
Circle 508 on Page 19

ANNOUNCING . . . NEW ADVANCED DESIGN POWER MASTER CYLINDER



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Low Friction, Non-Scoring, Phenolic Laminate
A Proven Bearing Material

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Leakproof cushion traps Pressure
Lip Lift *Eliminates* Ball Check

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POWER PRESERVER SEALS
Deep Base, *No Roll*, W Packing
Multiple Lip on Piston Rod

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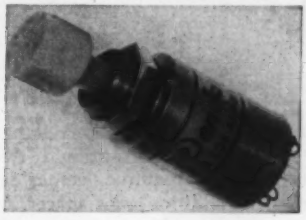
1½"—14" Bores, 12 Standard Mounts
Air—200 psig, Oil or Water—500 psig at 4:1 Safety Factor

"A BETTER CYLINDER AT LESS COST"
Ask for Petch Catalogue PMC58 or refer to Your Current Sweet's Product Design File.

PETCH PMC MANUFACTURING COMPANY
463 YORK STREET, DETROIT 2, MICH.

Circle 509 on Page 19

ing thread, 3/4-in. case diam, and 3/16-in. travel. It is rated 1/2 amp inductive at 28 v dc. Pushbuttons are available in various colors and shapes to meet individual require-



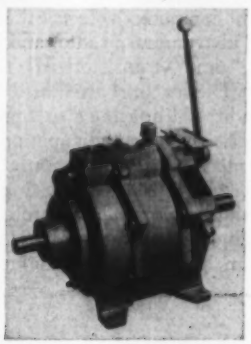
ments. **Switch Div., Pendar Inc.,** P. O. Box 3355, Dept. EE, Van Nuys, Calif. L

Circle 659 on Page 19

Reversing Transmission

has two forward speeds

Model 5231 reversing transmission transmits up to 28 hp at maximum recommended input speed of 2000 rpm. Reduction ratios are 1.97:1 and 3.35:1 in forward speeds and 3.37:1 in reverse. Unit, which provides two forward speeds, neu-



tral, and reverse, reverses smoothly under full load. Transmission is 15 11/16 in. long, 14 in. wide, and 14 3/4 in. high. **Industrial Div., Snow-Nabstedt Gear Corp.,** 251 Welton St., Hamden, Conn. B

Circle 660 on Page 19

Flange Ball Valve

serves as either 150 or 300-lb valve

Four-in-one Econ-O-Miser is ideal for limited-space applications. It serves as either a 150 or 300-lb valve where ASA dimensions are not required. Center section of valve is inserted between two standard

Ball retainers of antifriction

RULON A*

add extra life and extra use to antifriction bearings

A well-known bearing manufacturer, after testing many metallic and non-metallic materials for use as ball retainers, standardized on Rulon A to insure far greater service life for their bearings. Dixon's "superTeflon" contributes many performance advantages in this application:

- Because of its low coefficient of friction, the Dixon-supplied retainers help keep frictional heat to a minimum, guarantee low starting torque, and smooth vibration-free performance.
- Due to its engineered reinforcing, Rulon A provides high resistance to wear and deformation under load . . . assuring precise spacing of balls.
- Because of high thermal and chemical adaptability of Rulon A, the manufacturer now can offer bearings for the widest variety of service conditions. Rulon A retains its mechanical properties over −450°F to +550°F temp. range . . . has practically universal chemical inertness.
- The Rulon A retainers serve a dual role, having the ability to run completely dry—or to greatly extend performance with the use of lubricants.

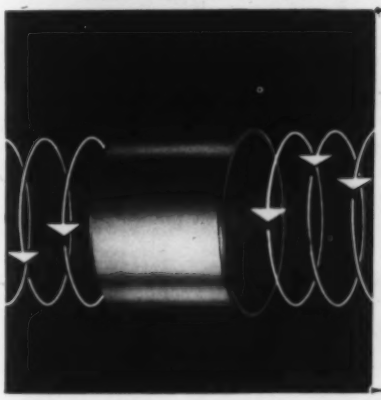
As in the development of these efficient ball retainers, Dixon's research and engineering groups are ready to assist design engineers in the successful and profitable application of Rulon to their products. Knowledge of standard or special reinforcing additives plus a broad experience in the manufacture of molded, extruded, or machined parts make Dixon the ideal source for sleeve bearings, bushings, thrust bearings, wear strips, cam followers, relay pushers, torque control bushings, and many other mechanical and electrical components. *One of Dixon's many modifications of Du Pont TFE Teflon

Write for Engineering Data Sheets on **RULON**

DIXON Corporation, Bristol, R. I.

Dixon

Suppliers of basic shapes and fabricated parts in Rulon and Teflon



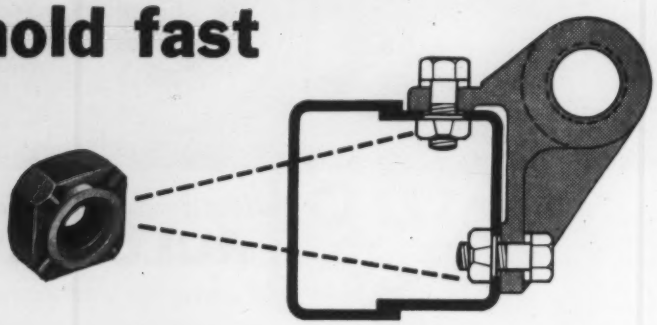
Shafts run smoother and longer on RULON T-LINER BEARINGS

Dixon's T-Liner Sleeve Bearing . . . with antifriction "floating" Rulon insert (modified TFE Teflon*) . . . is designed for applications that require high wear resistance with no lubrication. Available from stock in 10 standard sizes for 1/4" to 1 1/4" shafts. Bulletin 32-T gives full details on coefficient of friction (low!), chemical inertness (high!), and price (low!). Write **Dixon Corporation, Bristol, Rhode Island.** *Du Pont TM

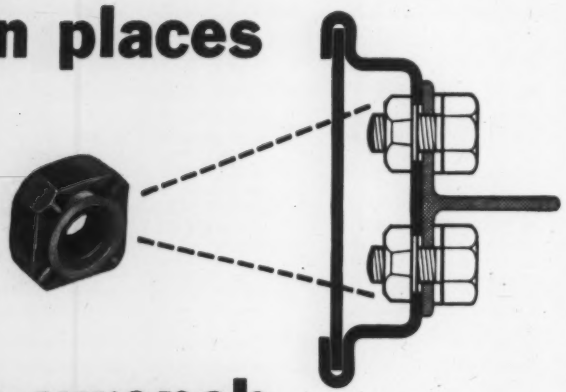
Dixon

Circle 510 on Page 19

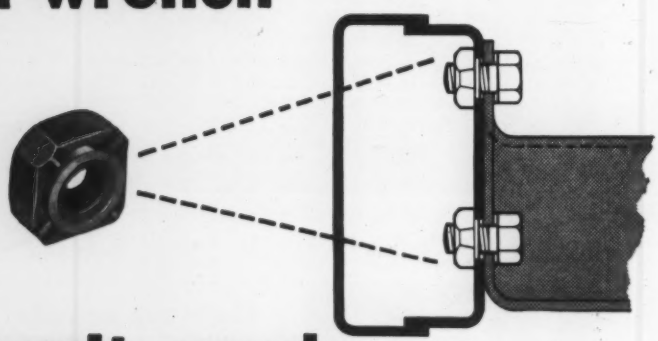
MIDLAND
WELDING NUTS
hold fast



in places



a wrench



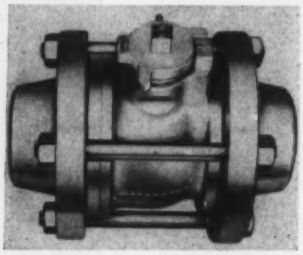
can't reach

Looking for cost and time-saving tips? Send for the free booklet showing you how to "Save With Midland Welding Nuts."

MR **MIDLAND-ROSS CORPORATION**
OWOSSO DIVISION • OWOSSO, MICHIGAN

MIDLAND WELD NUT

Circle 511 on Page 19



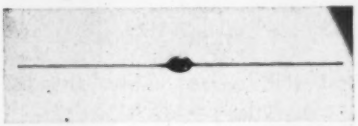
150 or 300-lb flanges and flanges are bolted together. Should ASA dimensions be required, center section, with addition of a spacer, becomes either a 150 or 300-lb ASA valve. Various combinations of seats, O-rings, and body materials permit unit to accommodate almost any medium within −100 to +400 F temperature range. **Worcester Valve Co. Inc.**, 16 Parker St., Worcester 10, Mass. B

Circle 661 on Page 19

Subminiature Diodes

have greater than 20,000-hr life expectancy

Subminiature selenium diodes, designated Minifiers, are for application in computers, electrical measuring instruments, radio and television, and transistorized equipment. Diodes are assembled in a drawn-brass housing to provide high-efficiency heat dissipation and good mechanical protection. They are coated with thermosetting material for environmental protection. Completed diodes are only 3/32 in. in diam and are fully insulated to



permit use where space is a limiting factor. When operated within ratings, useful life expectancy is greater than 20,000 hr. **International Resistance Co.**, 401 N. Broad St., Philadelphia 8, Pa. E

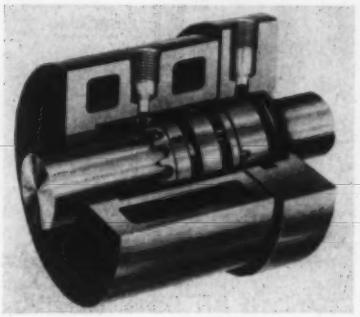
Circle 662 on Page 19

Mechanical Seal

continuously circulates stuffing-box coolant

Dura mechanical seal, incorporating circulating ring, is for use in pumps handling hot water or light hydro-

carbons. Seal circulates liquid from a stuffing box through a heat exchanger and returns it to stuffing box at reduced temperature. Seal keeps liquids below temperature that results in precipitation of salts, minerals, or other impurities, and reduces possibility of seals running dry. Seal is applicable to pressures of 600 psi and pumping temperature to 750 F, depending upon type of seal, shaft velocity, cooling ar-



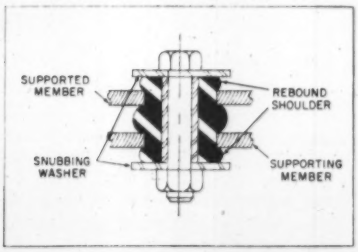
rangement, and lubricating qualities of liquid. **Durametallic Corp.**, 2104 Factory St., Kalamazoo, Mich. H

Circle 663 on Page 19

Elastomeric Mounting

one-piece unit has three compression sections

Double-extension mounting, for isolation of severe vibratory, shock, and related disturbances, is applicable to all types of mobile and portable equipment. Mounting is of one-piece construction, with elastomeric flexing element permanently bonded to steel inner member. Elastomeric end extensions are precompressed at installation to form two rebound shoulders for reverse loads. Shoulders, in combination with third compression section, provide excellent load-carrying and rebound characteristics. No lubrication or maintenance is required. Unit has superior radial flexibility and good axial restraint. Torsion-



Circle 512 on Page 19→

NOW! *Adjustable Diameter and Open* THOMSON

BALL BUSHINGS

Adjustable Diameter BALL BUSHING for Zero Clearance

The BALL Bearing for *all* your **LINEAR MOTIONS**

Precision Series "A" and Low Cost Series "B" BALL BUSHING

Open BALL BUSHING for Zero Clearance on Supported Shafts

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers and designers have solved this problem by application of BALL BUSHINGS on *guide rods, reciprocating shafts, push-pull actions,* or for support of *any mechanism that is moved or shifted in a straight line.*

Improve your product! Up-date your design and performance with Thomson BALL BUSHINGS!

LOW FRICTION • ZERO SHAKE OR PLAY
ELIMINATE BINDING AND CHATTER
SOLVE SLIDING LUBRICATION PROBLEMS
LONG LIFE • LASTING ALIGNMENT

The various types cover a shaft diameter range of ⅛" to 4". Small sizes available in Stainless Steel. Write for literature and name of our representative in your city.

THOMSON INDUSTRIES, Inc.
Dept. E, MANHASSET, NEW YORK

Also Manufacturers of NYLINED Bearings . . . Sleeve Bearings of DuPont Nylon, and 60 CASE . . . Hardened and Ground Steel Shafting

GEAR-GRIP

The most revolutionary Flexible Coupling Design Development in a Century!

(Actual size)

New Miniature Coupling

●

Now available for fractional and integral H.P.

●

Ability of rubber Flex-Element to float between captive end fittings distributing load similar to universal joint action.

- **LOAD RANGES—1/50 H.P. Thru 40 H.P.**
- **SHAFT SIZES—1/8" thru 1-7/8"**
- **COUPLING O.D.—.395" thru 3-7/8"**
- **Allowance of end thrust and specified exact over-all length per series among many design features.**

Dyna-Line

The finest flexible coupling in single unit construction—specifically designed for fractional H.P.

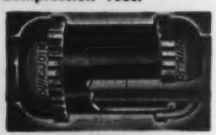
4R 3R 2R 1R OR OOR

- **LOAD RANGES—1/15 H.P. thru 1-1/2 H.P.**
- **SHAFT SIZES—3/16" thru 3/4"**
- **COUPLING O. D.—11/16" thru 1-9/16"**
- **Lengths varied to design specification in each series.**

Quick-Joint

Steel Compression Pipe Couplings

- **Now available in straight couplings, 90° Elbows, Reducing couplings, Male Threaded Adapters and Compression Tees.**
- **ALLOWS 14° Angular Deflection**
- **Guaranteed for 2000 PSI**
- **No threading of pipe required**
- **Various gasket compounds to meet hazardous and volatile fluid conditions**



Guardian PRODUCTS CORP.
COUPLING DIVISION
Dept. M-49
Michigan City, Indiana

Circle 513 on Page 19

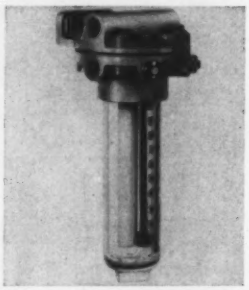
al disturbances, distortion, and relative motion are absorbed without loss of stability. **Lord Mfg. Co.**, West Twelfth St., Erie, Pa. F

Circle 664 on Page 19

Liquid Chemical Feeder

operates at flow rates from 0.1 to 4 gal per day

Micro-H chemical feeder, designed for use with hypochlorite solutions, defoaming agents, rust and scale inhibitors, wash-water detergents, slime-control agents and similar liquid chemicals, can be used wherever it is necessary to meter, feed, and regulate minute amounts of a given liquid chemical into another



liquid stream. It operates at low flow rates from 0.1 to 4 gal per day. Unit features a built-in ejector, corrosionproof plastic body, and porous stone to feed liquid chemical. **Fischer & Porter Co.**, 27 Jacksonville Rd., Hatboro, Pa. E

Circle 665 on Page 19

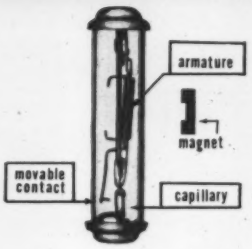
Remote Position Control

for rotary or linear actuators

D-52 Dialtrol provides accurate control, both remote and automatic, for valves, variable-displacement pumps, machine tools, or adjustable-speed drives. The low-cost unit has transistorized printed circuitry and new cabinet design. Positioner transmits control signal to shaft-mounted actuator which can be slipped on control shaft in place of standard handwheel or lever. Command is set in on a dial or on a counter-type setter. Automatic control is provided by liquid level, dancer roll, pressure transducer, or other signal device. Unit is designed for panel mounting or desktop use. Positioner also provides

NEW miniature encapsulated

"MAGNETIC" MERCURY SWITCH



Actual Size

CAPILLARY TYPE MAGNET OPERATED MERCURY SWITCHES

Moveable contact in the hermetically sealed switch makes contact by penetrating opening in the capillary tube (see illustration). Capillary tube is positioned so as to be supplied by the mercury in the well.

VERY LITTLE POWER REQUIRED TO OPERATE SWITCH

Adaptable to applications where a mechanical movement of approximately 0.007 (minimum) with a force of 2 grams is available to move the permanent magnet. Can be operated by small DC electromagnets for incorporation in electric or electronic equipment.

HIGH SPEED OPERATION

Speeds of 400 cycles per minute (at maximum rated load) are obtainable. Higher speeds are possible depending upon load characteristics.

VARIABLE MOUNTING ANGLE

Operation is possible even if switch is tilted as much as 45° from vertical position.

ELECTRICAL CONNECTIONS

Electrical connections to switch are made through the metallic-end caps, eliminating lead wires attached directly to the switch. They are however, available with lead wires of various lengths.

ELECTRICAL CAPACITY

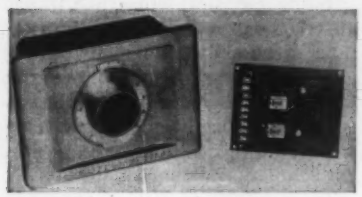
Type 6-81 normally open and Type 6-83 normally closed.

A.C. 115V., 0.3A.; D.C. 115V., 0.15A.

Write for Bulletin 6-81

THE MERCOID CORPORATION
4201 Belmont Ave., Chicago 41, Ill.

Circle 514 on Page 19



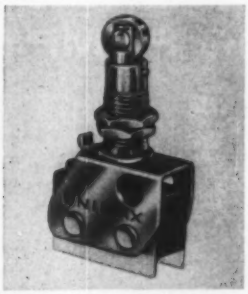
control for linear actuators, developing thrusts to several thousand pounds with stroke lengths to 40 in. **Jordan Co. Inc.**, 3235 W. Hampton Ave., Milwaukee 9, Wis. K

Circle 666 on Page 19

Subminiature Switch

for use where operating force is applied by a cam

Type 1SR1-1 subminiature, snap-acting switch is for use in many types of automatic equipment where operating force is applied by a cam. Stainless-steel roller provides long-wearing, low-friction bearing on actuating cam, and spring plunger permits 0.031 in. overtravel. Plunger is keyed to keep roller in line with cam. The 1/4-40 threaded bushing permits single-hole mounting in a



panel up to 1/4 in. thick. Unit is rated at 2.5 amp, 30 v dc, inductive; 5 amp, 30 v dc, resistive; 5 amp, 125/250 v ac. It has single-pole, double-throw action. **Unimax Switch Div., W. L. Maxson Corp.**, Ives Road, Wallingford, Conn. B

Circle 667 on Page 19

Electric Motors

are rated from 1 through 40 hp

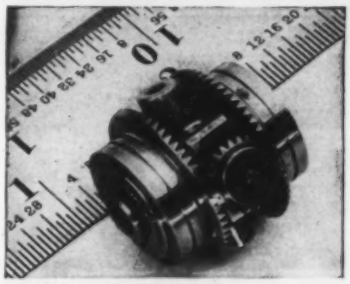
Rerated NEMA Type E, totally enclosed, fan-cooled electric motors are for use in nonexplosive atmospheres containing excessive moisture or abnormal quantities of dirt, metallic dust, or other abrasives. They

MICRO-BEARING ABSTRACTS

by **A. N. DANIELS**, *President*
New Hampshire Ball Bearings, Inc.

MINIATURE BEARINGS AND GEAR DIFFERENTIAL BACKLASH

(NOTE: We are grateful to W. J. Opocensky, Staff Engineer, Librascope, Inc., Glendale, California, for his factual report on the part played by our bearings in the design of the small two-pinion differential illustrated below.)



LIBRASCOPE 3/16" HOLLOW SHAFT DIFFERENTIAL uses special duplex MICRO-BEARINGS in all gears. Specifications are: Working circle 1.090", Length .980"; Input gear hole size .687", Starting torque .2 in. oz.—Maximum backlash 5 min. at 2 in. oz.

Miniaturization of precision ball bearings and gears is well advanced. However, putting them together to produce a small differential with low torque and backlash of five minutes or less is no simple task. Loads on single pinion differentials and on single ball bearings introduce objectionable flexibility. So does uncontrolled radial play in ball bearings whether used singly or in pairs.

After considering many designs, Librascope selected a two-pinion differential as the most logical type to develop. A "hunting tooth" gear ratio was also chosen to distribute wear evenly. Double bearings preloaded were to be used in all gears.

Special miniature bearings were developed to give duplex bearing performance at a cost only slightly higher than regular catalog prices.

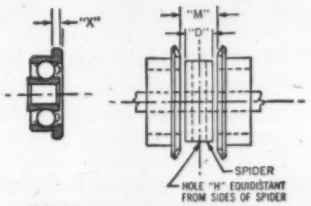


FIG. 1 FIG. 2

Dimension "X" in *Fig. 1* is coded in increments of .0002" under given axial load.

In *Fig. 2* the mounting distance "M" of the bevel gears is known. With the new bearing dimension "X" it is possible to determine the "spider" dimension "D". This provides the desirable mounting distance of bevel gears without shims.

To obtain maximum distance between raceways in limited space, narrow unshielded bearings were selected. To provide dust protection for the bearing a thin shim slightly smaller than the I. D. of the outer bearing race is used between bearing and Truarc ring. Truarcs are stainless steel double-disc-ground to various specific dimensions. With all dimensions controlled, bevel gears are accurately located from the pinion shaft hole, and any desired preload in the bearing can be obtained by selecting a Truarc of proper thickness.

Control of radial play of bearings in pinions presented a different, though similar, problem. Space limitations in the pinion are much more severe than with bevel gears. *Fig. 3* shows how Librascope solved the problem. Dimension "X" is coded in increments of .0001" with a given axial load, from inner race to outer race opposite the flange side on the one hand and opposite the ball retainer side on the other. A precision shim is used between outer races of the two bearings. By selection and use of new coded dimensions, any desired preload of bearings is obtained by fitting bearings to the shim.

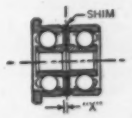


FIG. 3

To keep bearing races in mutual contact, another novel idea is used. Each pinion has its own adjustable shaft. The outside end of the pinion shaft is fitted with a Truarc. This rests against inner race of outside bearing. To overcome the limited adjustment of shims and expensive labor costs, a unique adjustable washer is used. By means of a special tool, each pinion may be adjusted for any desired amount of backlash. Bearings are held at preload by adjustable washer and Truarc. A clamping means secures pinion shaft to "spider".

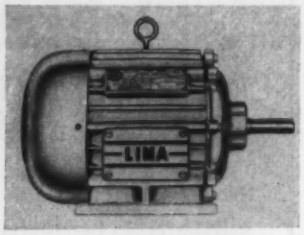
The Librascope differential design makes possible "5 minute" differentials at 2 in. oz. loads. Measurements are taken at *eight* equally spaced positions for one full turn of the "spider". The maximum backlash recorded determines classification of differential.

DESIGN HANDBOOK OFFERED FREE

You'll find this 70-page authoritative publication helpful in solving problems in designing instruments of small electromechanical assemblies. Write:

NEW HAMPSHIRE BALL BEARINGS, INC., PETERBOROUGH 1, NEW HAMPSHIRE

Circle 515 on Page 19



are furnished for standard horizontal, wall, or ceiling mount. All standard commercial frequencies and voltages below 600 v are available. Motors are available from 1 hp, 900 rpm (Frame 213), through 40 hp, 3600 rpm (Frame 326 U). **Lima Electric Motor Co. Inc.**, Dept. 139, Lima, Ohio. G

Circle 668 on Page 19

Epoxy Molding Materials

have excellent electrical properties

New epoxy molding materials can be molded in conventional compression and transfer molding equipment at temperatures of approximately 300 F and pressures as low as 75 psi. Molded parts show outstanding electrical properties which are retained under adverse conditions of humidity and high temperature. Resistance to hot caustic solutions is also excellent. Materials contain practically no volatile matter, resulting in blisterfree parts with superior dimensional stability after molding. Complete range of stable colors is offered. At present, mineral and dacron-filled materials are available. **Fiberite Corp.**, 510-524 W. Fourth St., Winona, Minn.

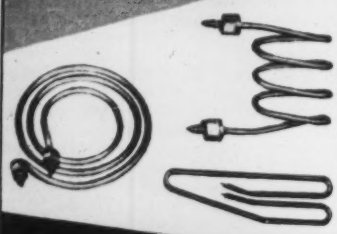
Circle 669 on Page 19

Hydraulic Operating Valves

for pressures to 2000 psi

Single-piston type Durable Seal hydraulic operating valves are available in sizes from ½ to 2 in. in three and four-way types, and up to 6 in. in two-way or spray-valve type. Same line pressure acts both inside and outside U-cup seals at all times during operating cycle. Seals are floated across ports without distortion, shear, or undue wear. There is no distortion of stainless-

VULCAN TUBULAR HEATERS



In the best of shapes

Here are just a few of the many shapes to which Vulcan Electric Tubular Heaters are formed. They are ideal for immersion in liquids, soft metals or molten salts. Straight, tubular heaters are easily clamped to metal surfaces or inserted in machined grooves. Vulcan Tubulars are easily cast into aluminum, iron or other metals. They can also be furnished with flattened surface for even more efficient heat transfer.

Vulcan Tubular Heaters are especially useful when you want a lot of heat in a little space. You have a wide choice of sizes — 10″ to 148″ (special — shorter or longer); diameters — .250″, .280″, .333″, .450″; wattage — 10 to 10,000 (or higher); voltage — standard 120 or 240, special 6 to 480 (or higher); sheaths — copper, steel, high temperature alloys.

Solve your hot problems with *Vulcan Versatility* in electric heat. Send coupon for catalog and prices.

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Danvers, Mass.

Cartridge • Strip • Tubular • Immersion Electric Heaters
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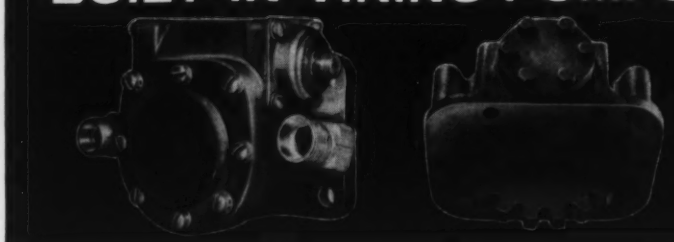
Circle 516 on Page 19

BUILT-IN VIKING PUMPS



CUT COSTS

for more and more manufacturers

Their ability to cut costs, while meeting exacting demands, influences more and more manufacturers to use Viking Pumps as integral parts of their equipment. Many are specially designed pumps, like the two shown here.

If you are looking for pumps with positive suction and smooth discharge, in any capacity from ⅔ to 1050 gallons per minute; pressures to 100 PSI on non-lubricating liquids, 200 PSI on lubricating liquids or 500 PSI on hydraulic oils, Viking Pumps are your answer. Furthermore, Viking Pumps answer your problems of designs, materials, speeds, variable capacities and suitability for handling thick or thin liquids.

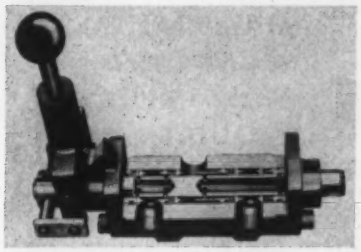
For information on Viking "built-in" pumps with pictures of applications, write today for Bulletin Form 409 H.

VIKING PUMP COMPANY
Cedar Falls, Iowa, U.S.A. In Canada, it's "ROTO-KING" pumps

See Viking Pump Booth No. 1610, Design Engineering Show, Convention Hall, Philadelphia, May 25-28

Circle 517 on Page 19

steel piston or of pedestals which position U-cup seals. Valves have low upkeep, long life, positive control, and easy operation. They are made with either screwed or flanged



pipe connections for direct hand operation, or in a choice of remote types, including solenoid or hand-operated air or hydraulic pilot valves. Valves are 88-10-2 bronze or steel for working pressures to 2000 psi. **Homestead Valve Mfg. Co.**, Coraopolis, Pa. G

Circle 670 on Page 19

Wire Cloth

in 120 to 400 mesh range

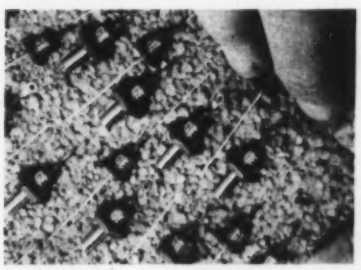
Square Weave wire cloth is available in 120 to 400 mesh range. Standard grades are furnished in monel and stainless steel. **Michigan Wire Cloth Co.**, 2100 Howard, Detroit 16, Mich. H

Circle 671 on Page 19

Silicon Rectifier Cells

have low reverse-current leakage

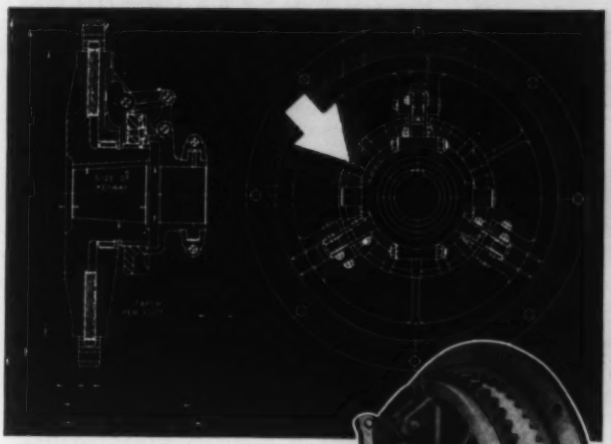
Fifty-eight additional types of low-current silicon rectifier cells feature low reverse-current leakage. Twenty of the units are pig-tail lead devices and 38 are stud-mounted types. All

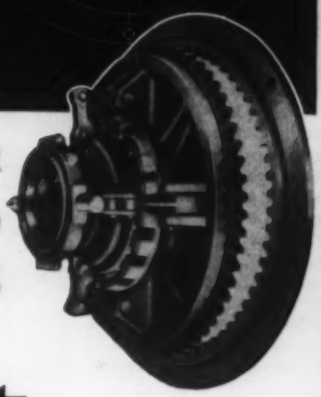


cells are alloy-junction silicon types and are hermetically sealed. **Semiconductor Products Dept., General Electric Co.**, Syracuse, N. Y. C

Circle 672 on Page 19

ROCKFORD





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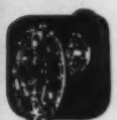
Gear Tooth Drive
CLUTCHES
Provide for
CLOSE ←
ADJUSTMENTS

Small Spring Loaded

Automotive Spring Loaded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Oil or Dry Multiple Disc

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Speed Reducers

A conveniently accessible adjustment ring provides for infinitely close adjustment—in ROCKFORD Over-Center CLUTCHES—without special tools. Fine adjustments can be made, and automatically maintained, without releasing or engaging separate locking devices which formerly limited adjustments to the spacing of notches or holes. This is but one of several exclusive features of ROCKFORD Over-Center CLUTCHES.

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Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

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311 Catherine St., Rockford, Ill., U.S.A.
Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

CLUTCHES

Circle 518 on Page 19

LOCTITE secures 98 studs against vibration

Locking studs with Loctite Liquid Sealant in transmission unit of jet aircraft starter.

Cast aluminum gear cases for jet aircraft starters are machined and assembled at The Black Rock Manufacturing Company, successor to Reed-Prentice Corp., Bridgeport, Connecticut. The 98 studs used in the unit are treated with LOCTITE Sealant to secure them against vibration. The jet starter units receive an input of 2500 rpm and develop output of 5000 rpm to each of three flexible shaft connections. LOCTITE was selected for this application since it provides a greater prevailing torque than any mechanical locking device. The locking strength of LOCTITE is not affected by the wide temperature ranges the unit encounters in arctic to tropic operation.

Stud thread is hand-dipped in shallow tray of Loctite, then positioned in casting for tightening. Three sizes of steel studs are used: ¼"-20, ⅛"- 18 and ⅜"-16.

Two ½"-14 thread inserts are treated with Loctite to lock and seal in casting. The inserts provide non-abrading threads for removable oil-drain plug.

LOCTITE Sealant is a thin liquid that hardens into a tough heat and oil-resistant plastic bond when confined between closely fitting metal parts. No amount of vibration will shake loose a LOCTITE treated threaded fastener, yet ordinary tools may be used to remove the part. LOCTITE is used to hold bearings, bushings, or hardened sleeves to shafts without press fit; seals joints against high pressure fluids. Write for literature and free sample.

LOCTITE® SEALANT

AMERICAN SEALANTS COMPANY

111 Woodbine St., Hartford 6, Conn.

See LOCTITE Booth 1653 Design Engineering Show

Circle 519 on Page 19

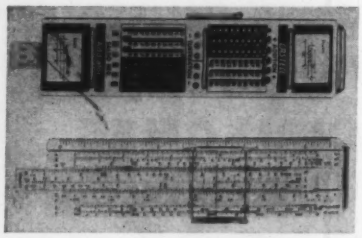
ENGINEERING DEPARTMENT

EQUIPMENT

Pocket Calculator

combines adding machine and slide rule

Pocket-sized calculator combines 13-scale log-log slide rule on one side with Addiator adding machine on the other. Slide rule has 5-in. scale length, is made from plastic that resists temperature changes to provide permanency and accuracy.



Adding machine is aluminum and brass. Calculator is furnished with instruction book and leather carrying case. Harrison Home Products Corp., 565 Fifth Ave., New York 17, N. Y. D

Circle 673 on Page 19

Electric Erasing Machine

uses 7-in. eraser inserts

Model 3831 hollow-shaft electric erasing machine, housed in a lightweight, die-cast aluminum housing with baked-enamel finish, has symmetrical contours and no sharp edges. Easy-to-hold unit features a nonslip gripping surface. Tapered shank permits easy manipulation in close quarters. Index-finger pressure on a switch sets eraser in operation

In a recent nation wide survey of honeycomb section manufacturers by an independent research organization, 75% of the responders indicated that uniform thickness of the thin metal core material was the most important factor demanded of suppliers.

With modern equipment, such as Accu-Ray gauges, Sendzimir rolling mills and unique vertical annealing furnaces, Somers combines 50 years of pioneering in the thin metal field to answer this problem with Somers Thin-Strip®, produced exclusively by Somers Brass Co., Inc.

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Circle 520 on Page 19

at 3100 rpm. Positive-lock chuck prevents eraser wobble or flyout. Seven-inch eraser inserts are firmly gripped at end by a chuck and chuck ring. Above the chuck, entire eraser length is contained in hollow core of shaft. Unit will erase pencil or ink, and can be used with any of five grades of eraser. Pencil-pointer attachment that fits into hollow shaft on back end of unit is for refillable pencils. **Charles Bruning Co. Inc.**, 1800 W. Central Rd., Mount Prospect, Ill. I

Circle 674 on Page 19

Audio Oscillator

provides stable audio output

Model 200 oscillator with self-contained power supply provides a stable, accurately calibrated source of frequencies between 30 and 30,000 cps. Unit generates a 10-v output into a 500-ohm load and has power attenuator for lower values. At 5-v output, distortion is less than 0.2 per cent. Frequency response better than ±1 db is provided over

30 to 15,000-cycle range with 500-ohm load, with stability exceeding 1 per cent, and very low harmonic content. No zero reset or line calibration is required, and dial calibration is accurate to ±3 per cent of scale reading. **Barker & Williamson Inc.**, Bristol, Pa. E

Circle 675 on Page 19

Digital Voltmeter

portable unit has 2.5 mv sensitivity

Available in 20 different models, Series A Digicorder measures millivolts accurately with both digital visual indication and direct remote electrical readout. The small, portable unit has available full-scale ranges of zero to 10 mv, 100 mv, 1

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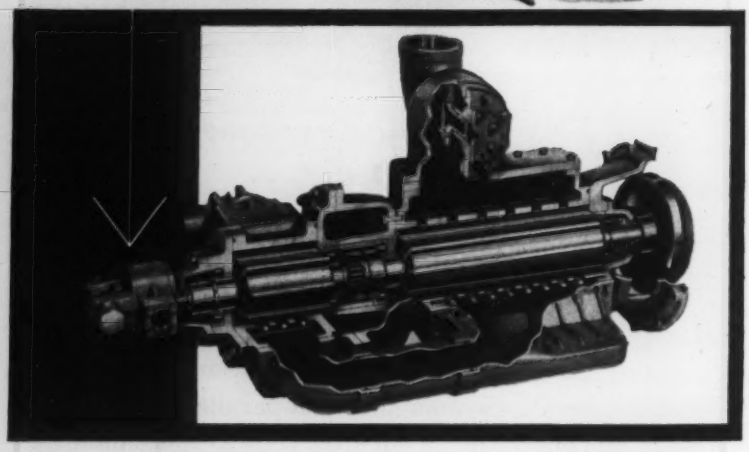
Circle 521 on Page 19

JAEGER DEPENDS ON
ROPER PUMPS
...so can you



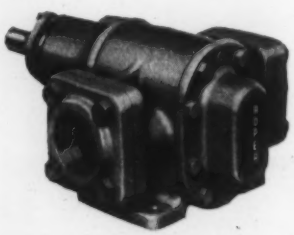
TWO STAGE ROTARY COMPRESSOR COOLED BY ITS OWN LUBRICATING OIL

Typical of Roper adaptability to heavy duty equipment is this installation on the Jaeger Roto Air-Plus, 2-stage rotary compressor. The pump sprays cooled, filtered oil onto the rotor and bearings in high and low compressor cylinders in order to lubricate all surfaces and seal against air leakage. The efficiency of the cooling system insures cool operation in ambient temperatures exceeding 100°. Arrangement of the system is such that oil-free air reaches the air service valve.

The Jaeger compressor has established service records of maintaining 100 lbs. constant pressure for 160 hours, without let-up — a tribute to the unit's dependability, and the Roper that helps cool it.

For OEM... Specify ROPER

In this instance, the Series K pump is suited to the Jaeger application. This series is available in sizes ¾ to 50 GPM, pressures to 150 PSI. It is a rotary gear unit, with sizes 10 through 50 featuring the patented venturi suction and discharge principle for smooth, quiet operation.



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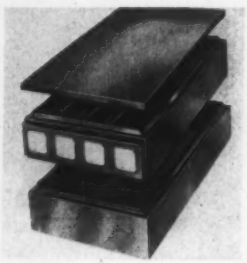
v, 10 v, and 100 v without use of external amplifiers. Sensitivity of better than 2.5 mv is provided in basic model, and accuracy of 1 part in 1000 is retained in all models through use of built-in mercury standard cell. Unit is useful in automatic data-logging applications, where an economical method of periodically monitoring strain gages, thermocouples, flow transducers, and process instruments is desired. It is 6 in. wide, 6½ in. high, 14½ in. deep. **Computer Equipment Corp.**, 1931 Pontius Ave., Los Angeles 25, Calif. L

Circle 676 on Page 19

Roll File

holds materials of unusual length



Basic Roll File, made of steel and containing four pasteboard tubes, has an add-on feature which permits stacking of units. Tubes are 2⅝ in. in diam, available in lengths from 24 to 60 in. at 6-in. intervals. Each steel unit includes a drop door with snap closure which provides for slip-in cards to identify material filed in each tube. Cards are available in white and eleven colors. Any number of basic units can be joined by fitting one over the other. Finishing tops and bases of steel are available. **Plan Hold Corp.**, 5204 Chakemco St., South Gate, Calif. L

Circle 677 on Page 19

Professional Viewpoints

. . . slugs and chugs . . .

To the Editor:

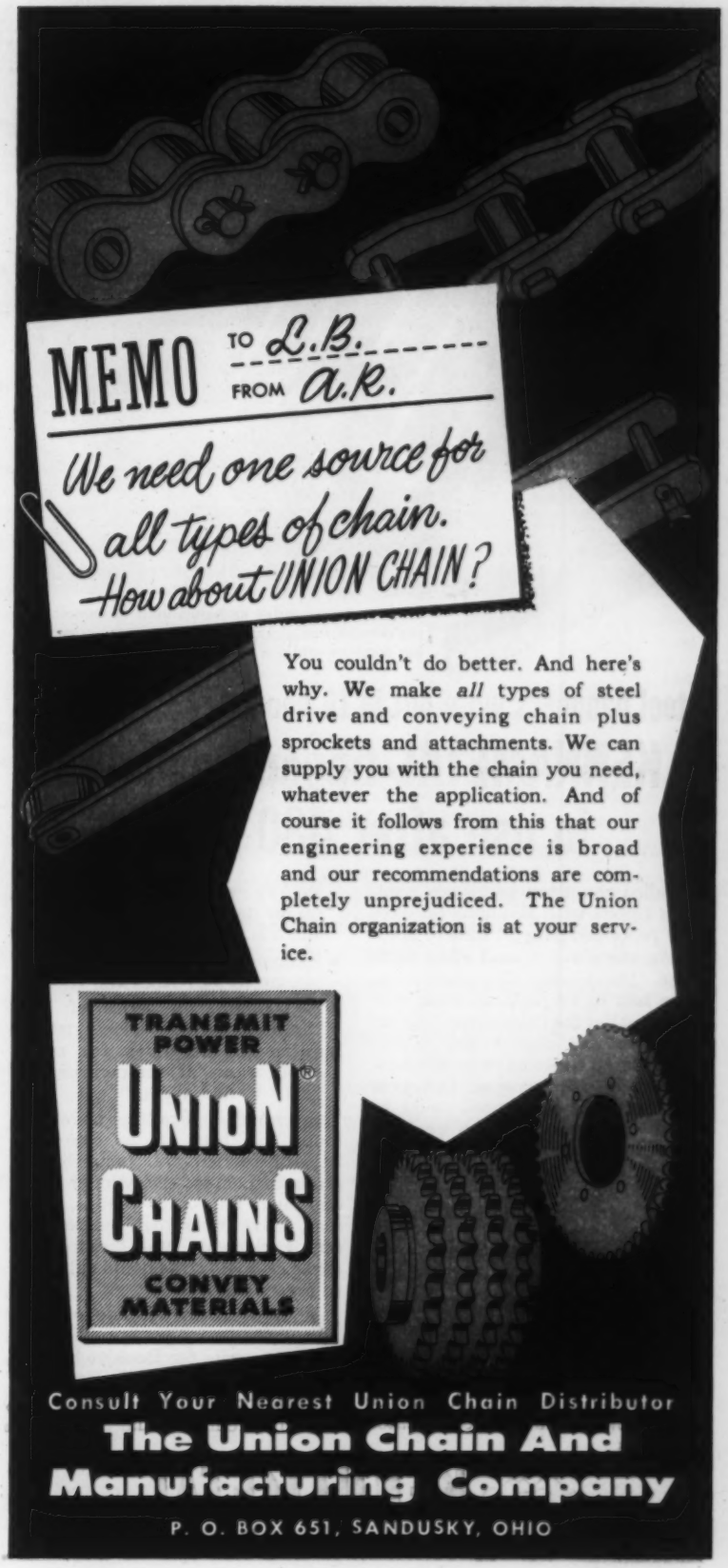
Strangely enough, the engineer has persisted in the use of certain measurement units inconsistent with his acceptance of the general nomenclature of physics. Use of pounds (English) and grams (metric) to measure force and weight is commonly in error. It has been long established by the physics texts that correct units of measure are poundals (English) and dynes (metric) for force and weight.

Careful distinction has been made by the physicist in naming pounds (English) and grams (metric) as units of measure for mass, that manifestation of resistance to change in state of motion. The definition has intuitively associated mass with force and weight in the engineer's mind, which accounts for his fallacious use of measurement units. The use of force on substance does provide a means, however, to sample or feel this "manifestation" of the property called mass.

Associated with mass is the concept of bulk (all matter has size) which also brings to mind density—that relationship between force or weight and cubic bulk.

Since from early times things have been weighed in terms of pounds, the English engineer, with some justification, insisted on retaining this unit to measure weight and likewise force. Because of this choice—inconsistent with the measurement units of physics—it became necessary for him to choose some different unit to represent a measure of mass. He called this unit the slug (even though the physicist would have it the pound). Thus we have the pound and the slug to measure force and mass, respectively, according to the engineer, as contrasted to the poundal and pound to measure force and mass, respectively, according to the physicist.

So be it—let us live with it and consider the slug. The engineer defines it as *that measure of resistance to change in state of motion which requires one pound force to cause a*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FROM A.R.
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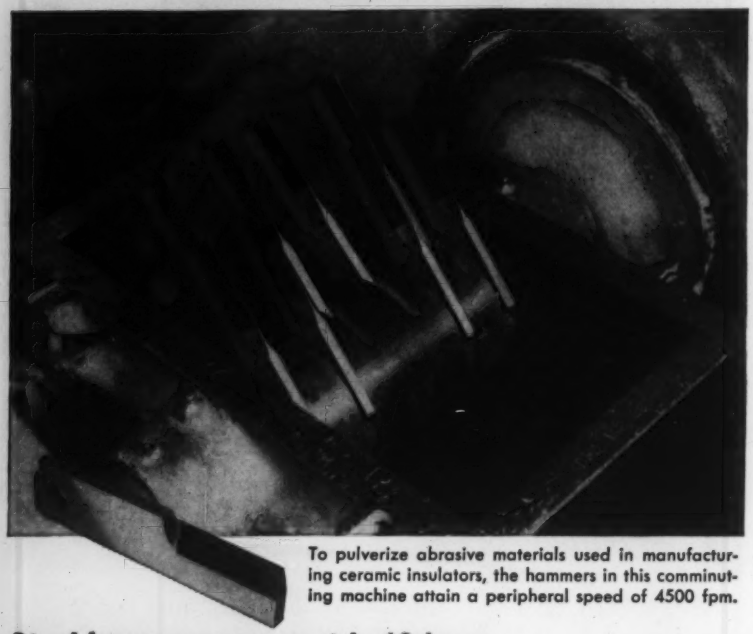
Circle 523 on Page 19

Wherever there's wear... there's a job for KENNAMETAL*



To pulverize abrasive materials used in manufacturing ceramic insulators, the hammers in this comminuting machine attain a peripheral speed of 4500 fpm.

Steel hammers wore out in 16 hours

KENNAMETAL-tipped hammers in use after 480 hours

Installed about two years ago, hammers tipped with Kennametal have now processed over 24 tons of abrasive materials . . . and show little wear. Previously, alloy-steel hammers had to be replaced after only 16 hours. Yet the Kennametal-tipped hammers cost only a few dollars more, for 30 times more production.

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- Kennametal is extremely hard . . . up to 94.7 Rockwell A.
- Kentanium,* a series of hard titanium carbide alloys, retains sufficient strength for many applications at temperatures of 2200° F. and above.

Very broad applications have been found for these unique characteristics of Kennametal. Long-wearing plungers, compressor cylinder liners, seal rings for rotary pumps, bushings, valve parts, high temperature sensor elements and hundreds of other critical components subjected to severe service.

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change in state of motion in the amount of one foot per second per second. State of motion is velocity or absence thereof, and change in state of motion is acceleration.

This discourse has already narrowed to the field of English system measurement units, to the exclusion of MKS and CGS metric systems of measurement. The foot-pound-second system of English units, in terms of which the slug ($W/32.16$ = slugs) is defined, has been found not entirely satisfactory to those mechanical engineers and others doing work in the field of applying servomechanism drives to automation machinery. Their calculations deal with distance normally thought of in the inch unit of measurement and velocities normally thought of in the inches-per-minute or inches-per-second units of measurement.

With this introduction, we would proceed to further degrade the physicist's correct usage of measurement units for force and mass by extending the "slug-notion" to the inch-pound-second system and to make it more compatible with the foot-pound-second system by coining a new measurement unit, and introducing it here with its new name, the *chug.* Twelve (little) slugs of mass make up one chug of mass. This is derived from the basic relationship: Force is equal to mass times acceleration, expressed as $F = MA$. Here the mass quantity M in chugs is the (force of gravity) weight in pounds of an object divided by the acceleration of gravity expressed as 386 in. per sec per sec ($W/386$). *The chug is that measure of resistance to change in state of motion which requires one pound force to cause a change in state of motion in the amount of one inch per second per second.*

There are 12 chug-in.^{2} to the bigger slug-ft^2 (multiply slug-ft^2 by 12 to convert to chug-in.^{2}). Also a pound force is identified as a chug-in. per sec^2 or a slug-ft per sec.^{2}

A switch to the chug, in. per sec^2, in. per sec, and in. for mass, acceleration, velocity, and distance now permits the older ft-lb-sec engineer to perform his same calculations without confusion and come up with a Simon Pure answer.

—T. A. WETZEL
Kearney & Trecker Corp.
Milwaukee, Wis.

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Chords are listed in this book of tables for circles with 3 to 100 equal divisions (in increments of 1) and diameters from 1/64 to 1 (in increments of 1/64) and from 1 to 100 (in increments of 1). Adding tabular values gives chords for diameters with any number of digits or combination of 1/64 increments, depending upon the accuracy desired of the five decimal tables. Also included is a similar table for circumferences and a fraction-to-decimal chart for 64ths.

New Standards

American Standard B5.12-1958, Twist Drills. *34 pages, 8½ by 11 in., paperbound, stapled; published by and available from The American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; $2.00 per copy.*

Scope of this standard includes nomenclature, definitions, sizes, and tolerances of two-flute straight and taper-shank drills and of combined drills and countersinks of both plain and bell type. Added to this revision are selected sizes of millimeter drills, screw-machine-length drills, and a list of drill sizes and their decimal equivalents. Drill names were changed for clarification, and the automotive drill series was deleted.

Association Publications

Welding Handbook, Section 2. *Edited by Arthur L. Phillips; 550 pages, 6 by 9 in., clothbound; published by and available from American Welding Society, 33 West 39th St., New York 18, N. Y.; $9.00 per copy.*

This section of the fourth edition deals with gas, arc, and resistance

welding processes. Separate chapters describe equipment used for each process or group of processes. Revised, standard welding symbols and nondestructive testing symbols are presented for the first time.

Section 1 on welding fundamentals was published late in 1957. Proposed publication of the last three sections of the handbook, one each year, will cover miscellaneous metal-joining, cutting, maintenance processes and practices, metals, and welding applications.

Proceedings of the Third U. S. National Congress of Applied Mechanics. *Edited by R. M. Haythornthwaite; 864 pages, 8½ by 11 in., clothbound; published by and available from American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; $20.00 per copy.*

This volume contains complete texts of four general lectures and 97 technical papers as presented at the Congress sponsored by a committee of seven professional societies and by universities, institutes, federal agencies, and industrial corporations.

Papers are grouped into four categories: 1. Dynamics, vibrations, elastic waves. 2. Elasticity, elastic structures. 3. Plasticity, viscoelastic flow, fracture. 4. Fluid flow, aerodynamics, heat transfer.

Charts, graphs, and photographs are included in this latest coverage of research results, theoretical and statistical methods, correlations, unique approaches to difficult and unusual problems, analytical tools, original viewpoints, background information, and recommended bibliographies.

Manufacturers' Publications

Technical Illustration. *90 pages, 8½ by 11 in., paperbound; available from Higgins Ink Co. Inc., 271 Ninth St., Brooklyn 15, N. Y.; $2.50 per copy.*

Design sketching and perspective drawing for modern industrial use are described. Graphic presentation is illustrated with assembly drawings; cut-away, exploded, and phantom views; and overlays. The book also covers lettering, shading, inks, pencils, templates, drafting machines, and optical devices.

Cardinal Manufacturing Co., Kansas City, Kansas

An Unusual Problem . . .

How to dry picture tubes quickly—*from the inside*—after pouring screen. Natural drying had proved too slow—not only from an output standpoint, but also because the screening material lost its strength unless dried quickly. Narrowness of the necks of tubes posed a further problem . . . eliminated the use of conventional drying methods.

A Practical Solution . . .

A Spencer blower was arranged to deliver air at the required 165°F, utilizing controlled heat of compression. This heated air is carried through insulated lines to individual jets (each with multiple outlets) at rack-table arrangements. 110 tubes are processed simultaneously. Drying time of only 8 to 12 minutes is required.

BLOWER SPECIFICATIONS
TYPE: Spencer Turbo-Compressor
H.P.: 15
AIR DELIVERY: 450 C.F.M. @ 4 p.s.i.

Drop a line for information on how a Spencer blower—standard or specially adapted—might help solve your product or process design problem. Spencer blowers are available in standard capacities for 1/3 to 1,000 H.P., volumes up to 20,000 C.F.M. pressures 4 oz. to 10 lbs.

Request Catalog 126A containing complete specifications on Spencer Blowers.

The SPENCER TURBINE COMPANY
HARTFORD 6, CONNECTICUT

Circle 526 on Page 19

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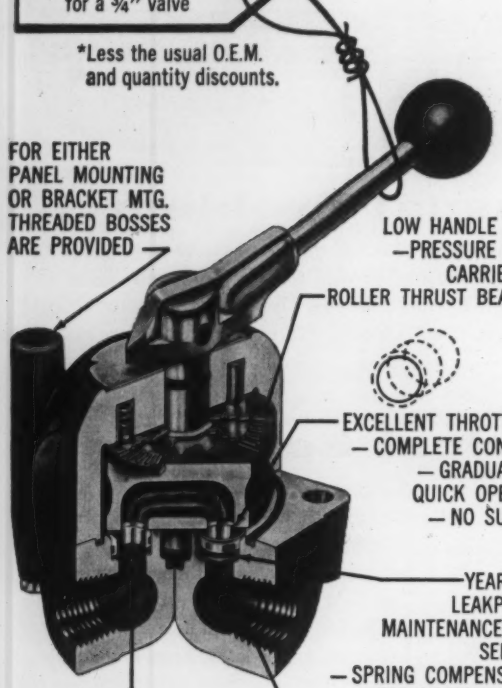
A "SHEAR-SEAL" VALVE

for LESS than a spool valve

RATED FOR 3000 P.S.I. OIL SYSTEMS

$65.00
List Price*
for a ¾" valve

*Less the usual O.E.M. and quantity discounts.


FOR EITHER PANEL MOUNTING OR BRACKET MTG. THREADED BOSSES ARE PROVIDED
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MORE FLOW THRU UNOBSTRUCTED ROUND FLOW PASSAGES
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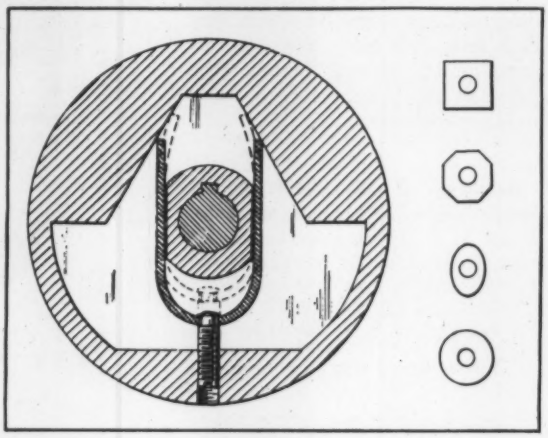
CONTROL VALVE DIVISION

Barksdale valves

5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

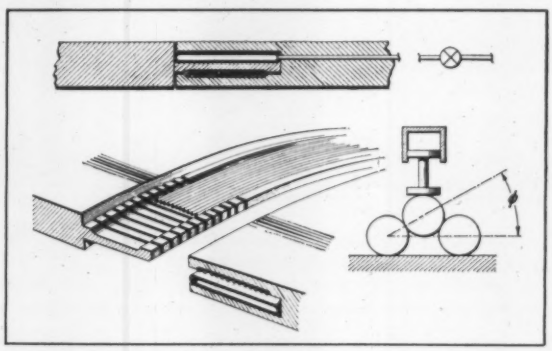
NOTEWORTHY Patents

Adjustable Overload-Release Clutch



Flexure of a U-shaped spring between driving and driven members accommodates overload, whether momentary or prolonged, in either direction of rotation. A flat-sided member, keyed to a power shaft, cams the spring open farther when overload occurs. To change the value of critical overload, the spring can be repositioned radially by a setscrew, or the member spanned by the spring can be replaced by others of different shapes. *Patent* 2,826,903 *assigned to Centric Clutch Co., Woodbridge, N. J., by Henry D. Gerstung and Edward T. Malmros.*

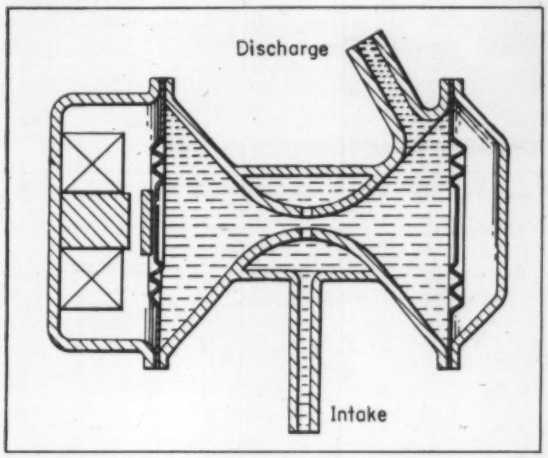
Detachable Large-Tube Joint



Split rings, wedged together under load, form a fastening, quickly engaged and disengaged, for relatively large and heavy tubular members. Projecting from one tube, flexible tongues have a circumferential recess filled with split rings. The rings grip the recess by their own spring force. In the adjoining tube, an opposite recess is filled with rings also held in place

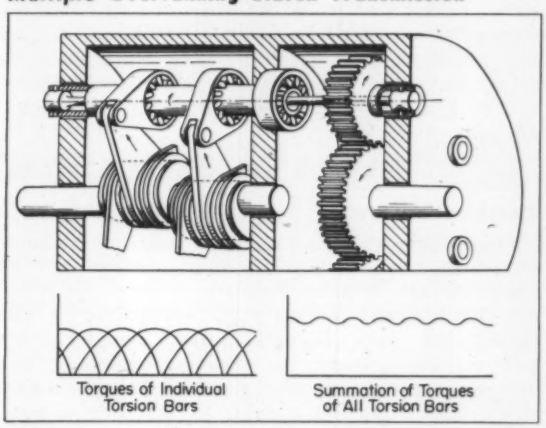
by their own spring force. When the tubes are connected, the rings intersperse. The pressure of fluid pumped into a circular tube, elongated in section, jams the rings together, thus joins the tubes. *Patent* 2,827,-312 *assigned to the United States of America (Navy) by Sidney H. Spencer.*

Venturi Pump

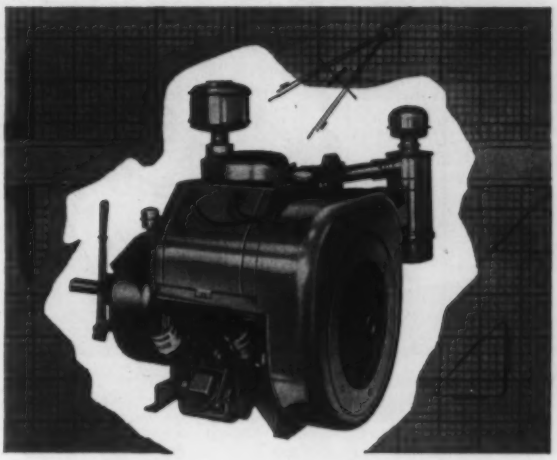


Small quantities of liquid are delivered against a relatively low head by a pump in which principal functioning elements are a perforated venturi and two flexing diaphragms. One diaphragm is flexed cyclically by a means such as a magnet. This flexure, in either direction, moves fluid axially through the venturi. Consequent suction moves fluid from an intake into the venturi through small holes, thence to outlet. Surges of pressure are damped by the second diaphragm. *Patent* 2,872,877 *assigned to Ford Motor Co., Dearborn, Mich., by Richard D. Brewer.*

Multiple Overrunning-Clutch Transmission



Compact size and small amplitude in the variations of overall torque output are provided by a multiple overrunning-clutch power transmission. Input torque is transmitted from a single central crankshaft, through



Let **"Wisconsin"** *Engineers help you develop a* complete power package for your equipment

You start with a rugged, heavy-duty WISCONSIN AIR-COOLED engine. Compact and light weight to reduce bulk and fit your equipment. High torque for load-lugging power. Air-cooling for all-weather serviceability in any climate, any weather, anywhere. Here are the "extras" available from Wisconsin to complete the "power package" to most ideally suit your requirements:

DRIVE: Centrifugal clutches; over-center clutch; clutch reduction with various ratios; reduction assemblies; adapters to take a spring-loaded clutch and transmission or torque converters.

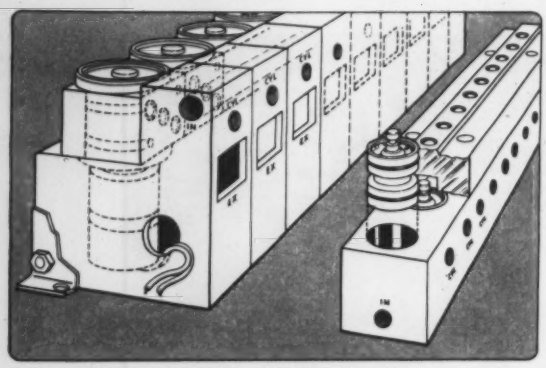
SPEED REGULATION: Your choice of many types of governor controls . . . hand operated remote wire and lever controls; 2-speed agricultural controls (idle and load speed); provisions to mount controls of your own design.

FUEL SYSTEM: Gasoline and LPG for domestic applications; alcohol, kerosene, No. 1 fuel oil or kerosene for export (or as specified).

HYDRAULIC POWER: All Wisconsin 4-cylinder models can be equipped with integrally mounted hydraulic pump.

ELECTRICAL EQUIPMENT: 6- and 12-volt electric starters and generators for all models, 3 to 56 hp. Solenoid switches and automatic choke for remote or automatic starting.

Let us help you build the right Wisconsin Engine into your equipment . . . *power to fit the machine and the job.* Tell us about your problem. We'd like to co-operate. For a briefing on the Wisconsin engine line, write for Bulletin S-237.

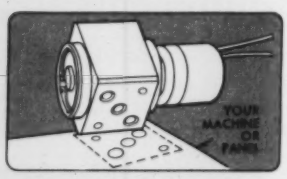


New Humphrey "Stack-Pack" Electric Manifold Valve. May be used singly or in multiples. Valve mechanism easily removed from manifold. Single inlet port for multiple installations.

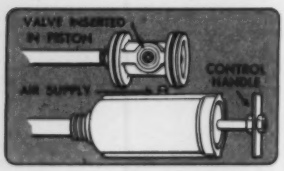
Humphrey Exclusive! Manifold using Insert Valves. Just the internal mechanism of valve may be inserted in your manifold. Manual, cam or pilot operated.

HUMPHREY "Quick-Dump" VALVES

give you greater capacity—smaller size—faster action—more versatility and simplicity of design



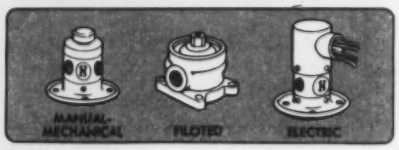
This may be the valve you need! Square bodied Electropact or piloted valve with all porting on one side to mate with drilled air* passages in your product, or—mount on panel with all porting on one side. Greatly simplifies installation.



For original equipment, "Quick-Dump" Valves offer outstanding advantages. This customer's air cylinder is operated by two Humphrey Valves inserted in piston itself! A turn or pull of handle controls piston travel.

OFFERED IN THESE BASIC TYPES—

ACTUATED BY ANY OF THESE METHODS—



***FOR AIR, WATER, OIL, GASES—TO 125 PSI**

⅛" delivers 30 CFM at 100 PSI • ¼" delivers 80 CFM at 100 PSI • ½" delivers 275 CFM at 100 PSI • Dead seal shut-off. Temperatures from -65° to 225° F. 2-3-4 way—⅛", ¼", ½" sizes. Write for engineering assistance on your valving problems.

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DIVISION OF GENERAL GAS LIGHT COMPANY "The Heart of Automation"

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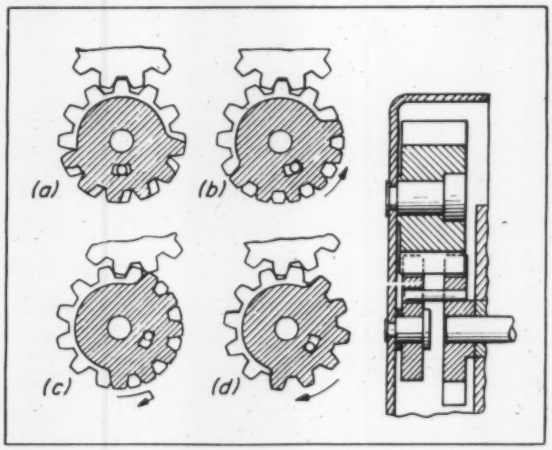
Pneumatic-Hydraulic Valves and Devices

connecting rods, to cranks. Each crank houses an overrunning clutch which is mounted on a tubular shaft. Several clutches are carried on each of several tubes parallel to and uniformly spaced around the crankshaft. Torque from the clutches is transmitted from each tube to a torsion bar in the center of the tube. The bar carries a gear engaged with a central collecting gear at the output end. Angular staggering assures that clutch cycles overlap and that no one clutch ever carries full torque. *Patent* 2,864,259 *assigned to Bendix Aviation Corp., Teterboro, N. J., by Henry Troeger.*

One-Way Gear Drive



Rotation of a synchronous motor in only one direction, as in a clock, is assured by action of a gear segment which blocks rotation in the wrong direction. A pin fixed in a driving pinion passes through a slot in the segment, coaxial with the pinion, *a*. Length of the slot allows the segment to travel an arc of 1½ teeth with respect to the pinion. In the wrong direction, the segment is out of phase, *b*. Impact with an idler reverses rotation, *c*, to the direction in which the teeth of the pinion and segment are aligned, *d*. *Patent* 2,874,809 *assigned to General Time Corp., New York, by Arthur B. Poole.*

Combination Brake

On a single wheel, a tread-type brake and a drum-type brake function simultaneously through proportioned linkages actuated from a common power cylinder. The cylinder encloses a pair of opposed pistons, fluid-driven. Both linkages include complementary members which assure that adjoining friction surfaces are always parallel. Friction members include external shoes which engage the wheel tread, and internal shoes which engage the ID of the drum. The drum is bolted onto the outboard wheel surface and carries annular cooling fins. *Patent* 2,873,821 *assigned to American Steel Foundries, Chicago, by William Mann and Bernard Maloney.*

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Write for your free copy of Gleason Catalog, Industry's most complete "Idea Book" on profitable application of Gleason Spring Reels, Motor Reels, Hand Reels — for electric cable, cord, and hose Control for all equipment in motion. Or write for engineering suggestions.

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SPRING REEL HEADQUARTERS FOR ALL INDUSTRY

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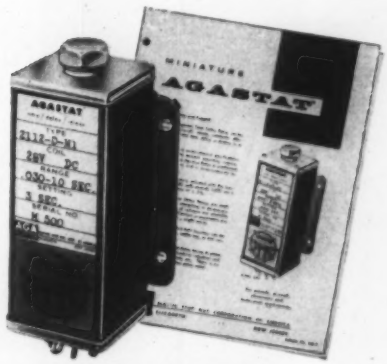

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time/delay/relays

This free folder contains complete specs on 24 models of the miniature AGASTAT Time Delay Relay for missile, aircraft, computer, electronic and industrial applications. They're small as 1-13/16″ x 4-7/16″ x 1½″, with adjustable timing ranges starting at .030 and as high as 120 seconds.

The folder gives operating and environmental specs, coil data, contact capacities, dimensions, diagrams of contact and wiring arrangements. *Write:* Dept. A33-428.

AGA ELASTIC STOP NUT CORPORATION OF AMERICA

Elizabeth, New Jersey

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Versatility plus application ease make "SCOTCH-TRED" a stimulating IDEA material for more creative product design

FUNCTIONAL! Textured "SCOTCH-TRED" surface has high capabilities in slip and skid elimination. Resilient under pressure . . . extra long-wearing . . . non-sparking. *Decorative!* Modern soft colors—beige, gray, black—harmonize with any scheme. *Versatile!* "SCOTCH-TRED" conforms smoothly to almost any surface; can be cut with scissors, knife, or die; pressure-sensitive adhesive sticks at a touch. Available in ¾″ x 24″ strips; 9″ squares; bulk 96-foot rolls, from 4″ to 36″ wide. See Sweet's Product Design File insert 4b Mi.

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"SCOTCH-TRED" non-slip surfacing is made in U.S.A. by 3M Co., St. Paul Minn. Export: 99 Park Ave., New York 16. Canada: London, Ontario.

MINNESOTA MINING AND MANUFACTURING COMPANY 3M

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

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Please rush free sample of "SCOTCH-TRED".

Name_____

Firm_____

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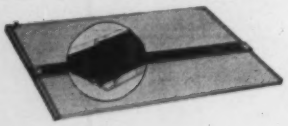
MAYLINE



The Best Possible Combination

A Mayline straightedge and a Mayline table. Mayline straightedges are made from moisture resistant black satin laminated phenolic plastic. Transparent edges are crystal clear. Available in 30" to 96" lengths. Straightedges completely described in Folder S-15.

These fine straightedges attached to the May-O-Matic table make an incomparable combination. The May-O-Matic top is adjustable for height positioning and required angle of drawing position. It is available in 10 combinations. This amazing table explained in detail in Folder S-22. Send for both folders today.

MAYLINE

MAYLINE

MAYLINE CO., INC.

601 No. Commerce St.

Sheboygan, Wisconsin

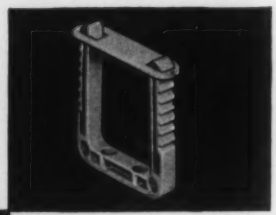
MAYLINE

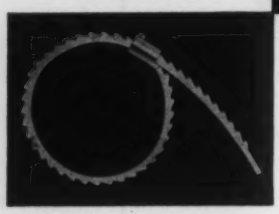
Circle 533 on Page 19

TO SECURE WIRES & WIRE BUNDLES

DAKOTA

Nylon
CAB-L-TITE* CLAMPS
and
BUND-L-TITE* STRAPS





- Lightweight
- Fast and easy to install
- Positive holding power
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- Reliable

Real weight and space savers, Dakota clamps and straps are made from DuPont zytel to insure extra strength, extra reliability under extreme loadings. Thoroughly proven in aircraft and missiles. Dakota securing devices find countless applications throughout industry. Bayonet hangers for fixed strap installations and high speed bundle-tie pliers are also available.

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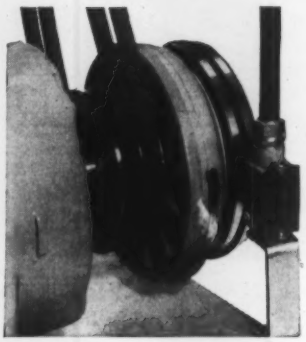
automatic clutch



engages at any speed

actuation in a package!

Electromagnetic principle gives you complete freedom in the use of automatic controls for engaging and releasing a machine drive. Actuation is direct from a 6 or 90 volt, d-c power source to the torque-producing clutch field. Operates at any motor or shaft speed. There's no easier way to control power automatically or by pushbutton—no faster way to cycle a machine for fine-increment jogging. Write for Catalog No. 6292.

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Warner Electric Brake & Clutch Co.
Beloit, Wisconsin

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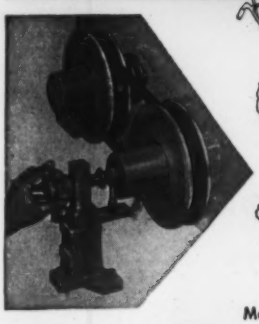
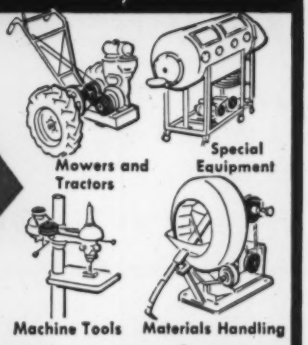
VARIABLE PITCH SHEAVES

Control Speeds on Variety of Machines





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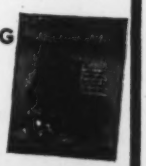

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GLIDER-ABILITY!!

GLIDER® Vertical Blue Print Files

Up to 1800-print capacity

GLIDERS merge functional design with the strength of steel for faster filing of more plans in less space. Within the straight line styling of gleaming gray GLIDER frames, there are other "profit-abilities"

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GLIDER plan holders, 20" to 48" long, hold up to 100 prints each. Spaced thumbnuts provide direct clamp control. Single and multiple sheets or sets are held equally firm.

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"T"-tops of each plan holder "glide" into and out of, rigid, steel channel-tracks. As print quantity increases, users add extra plan holders. A capacity of 1800 prints may be retained in the GLIDER 48" x 36" x 60".

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For greater plan filing purposes, there are GLIDER Extensions. Available in 32" and 48" lengths, they're easily attachable to original GLIDER units or other Extensions. Filing space is increased by one, or more, of the same units at reduced cost.

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*Patented by MOMAR Industries

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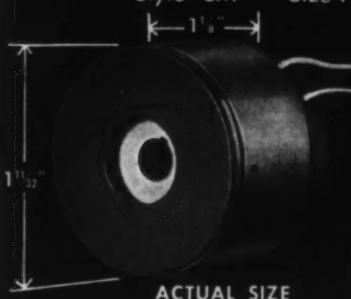
Style "SM" — Size No. 2



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Weight — 5.2 oz.
Stationary Field
Plug-in Connections
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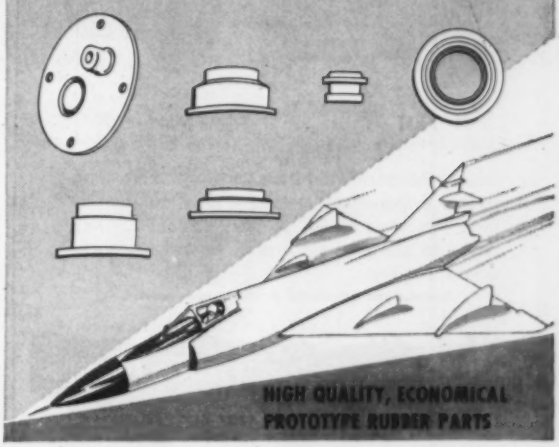
MINNESOTA MR RUBBER

PROTOTYPES by KOTOKAST®



CLOSE TOLERANCES—Tolerances are identical with those that will be found on standard production parts. Thus you can be absolutely certain that the results of your testing program will give the sort of accurate information you want.

FAST SERVICE—Usually it will take only hours from the time the order is received to produce twelve prototype parts using PROTOTYPES by KOTOKAST. It gives more flexibility in your testing and relieves you of the burdensome worry about deadlines.

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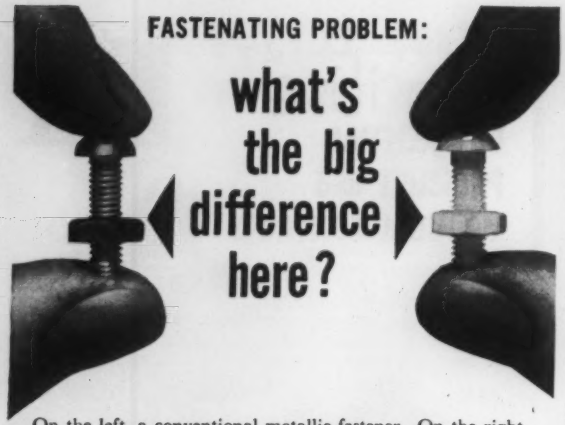

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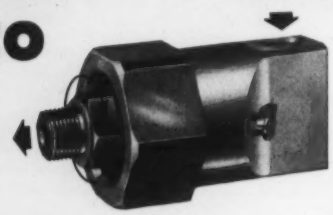

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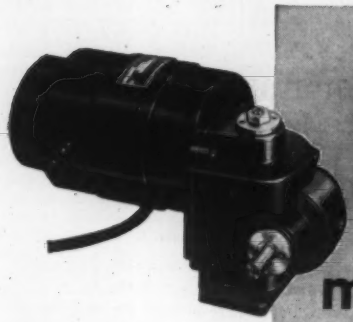

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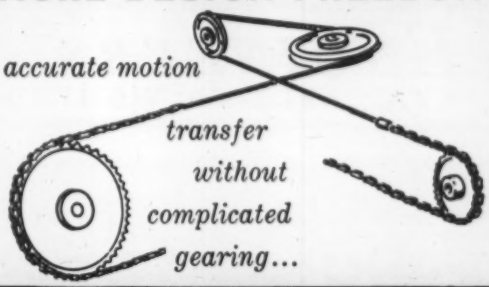

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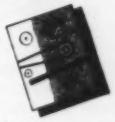

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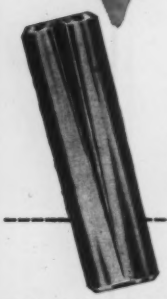

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World Bestos Division of the Firestone Tire and Rubber Co. 168

Engineers Available or Wanted 196

Music and fun in the children's ward —on Junior Red Cross Visiting Day.

One "Youth Gang" we need more of...

Rock 'n rollers? That's right. *Rock 'n rollers in a children's hospital.*

The three "gang members" are Junior Red Cross members who've taken an afternoon of their time to go to the hospital and entertain some little crippled kids. Reassuring, isn't it?

They do things like this all the time. Regularly. Girls and boys.

20 million of our sons and daughters make up Junior Red Cross—the largest youth organization in the country. Junior members take part in every one of the Red Cross service programs that young people can help to carry on.

When disasters hit, Junior Red Cross volunteers help in many ways—as messengers, typists, canteen workers, information clerks. Many Junior Red Cross members have served with real distinction in disaster emergencies.

Through the Gift Box Program in their schools, Juniors send relief supplies to children overseas. Like all Junior Red Cross activities, this program is financed entirely by the Juniors themselves.

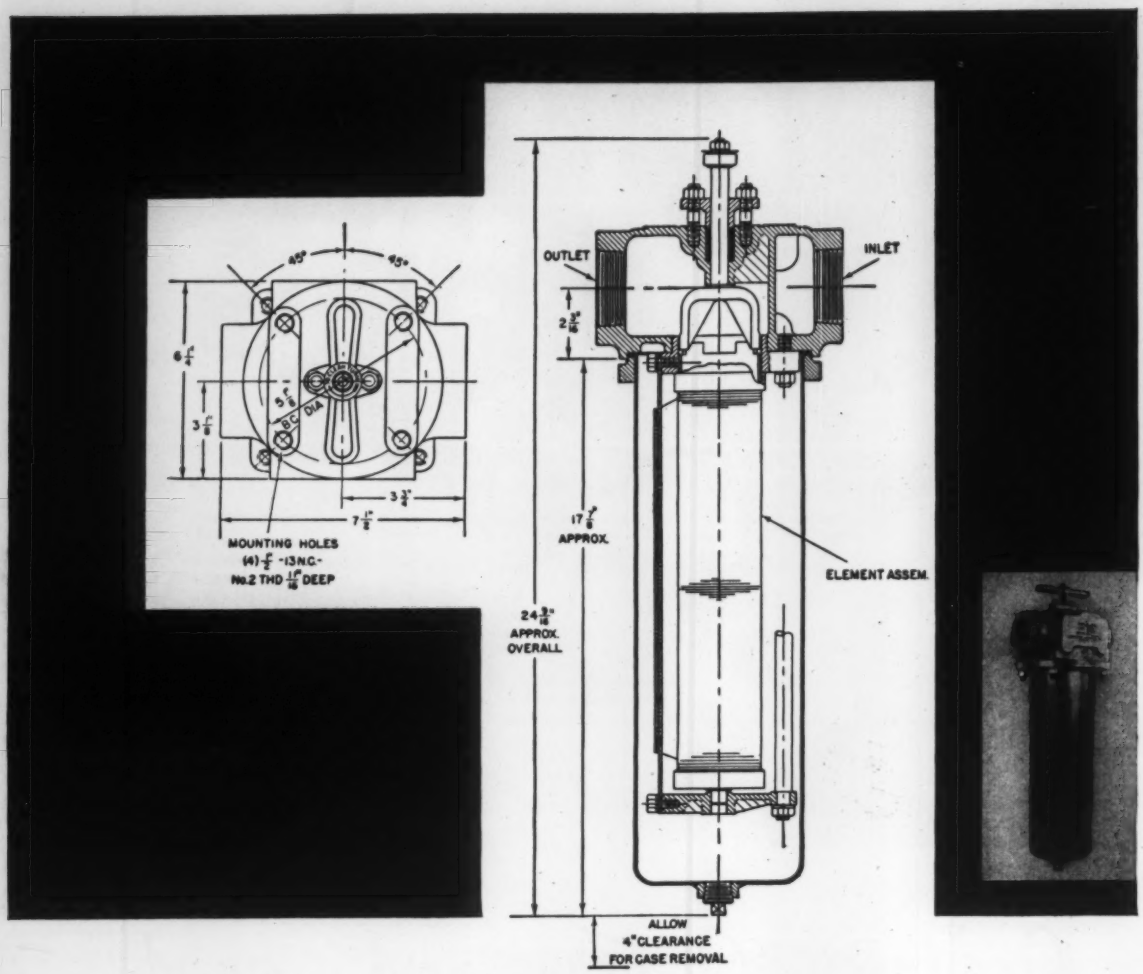
Friendship between children all over the world is fostered by the Junior Red Cross correspondence-album and art programs.

Junior Red Cross is at work every day, helping to build a strong, decent, responsible young America.

These are kids we don't have to worry about. Let's be sure they know they can depend on *us.*

Join

On the job when you need it most



This one standard Purolator filter is

EXACTLY RIGHT *for all these fluids:*

inks • paints • varnishes • food products • greases • process fluids • fuel and lube oils

SPECIFICATIONS: This Purolator filter model G-141J—is designed for filtration in a range upward of .40 microns.

It can be installed on pressure or suction side of pump.

It is recommended for capacities of from 6 to 200 GPM, dependent on viscosity. Spacing varies from .0010 to .020.

Relief valves set from 10-12 (generally 15 to 20) to 50 PSI are incorporated in several models.

Motor driven knife blade to clean element can be furnished whenever conditions make manual rotation impractical.

Maximum pressure: 125 PSI; weight: 37 lbs. Equipped with simplex full-flow metal element oil strainers.

Available in all stainless steel construction for corrosive liquids, process fluids, food products.

If this filter's specifications recommend it for a problem of yours, write for application information.

Filtration For Every Known Fluid

PUROLATOR

PRODUCTS, INC.

RAHWAY, NEW JERSEY AND TORONTO, ONTARIO, CANADA

Circle 556 on Page 19

View of the huge Cleveland Worm and Gear set used in this 150 Series All-Steel Shear, built by The Cincinnati Shaper Co.

CLEVELAND gearing helps this giant shear 1½" steel plate

THE terrific pressures generated in cutting a 1½" steel plate 12 feet long are as nothing to this giant shear. Reason: Because there is plenty of extra power, transmitted through Cleveland Worm Gearing.

Whenever a drive must operate under extreme pressures, there you'll find Cleveland Worm Gearing at its best. And a Cleveland drive stays dependably on the job no matter how severe the service. It doesn't wear out—its efficiency actually improves with use.

Write for Bulletin 145 which illustrates the many types and sizes of units available in Cleveland Worm Gear Speed Reducers and Drives. Our sales representative near you will sit down with you at your convenience to analyze your drive problems and help you select Clevelands best suited to your needs. The Cleveland Worm and Gear Company, 3287 East 80th Street, Cleveland 4, Ohio.

Subsidiary of Eaton Manufacturing Company

Affiliate: The Farval Corporation.

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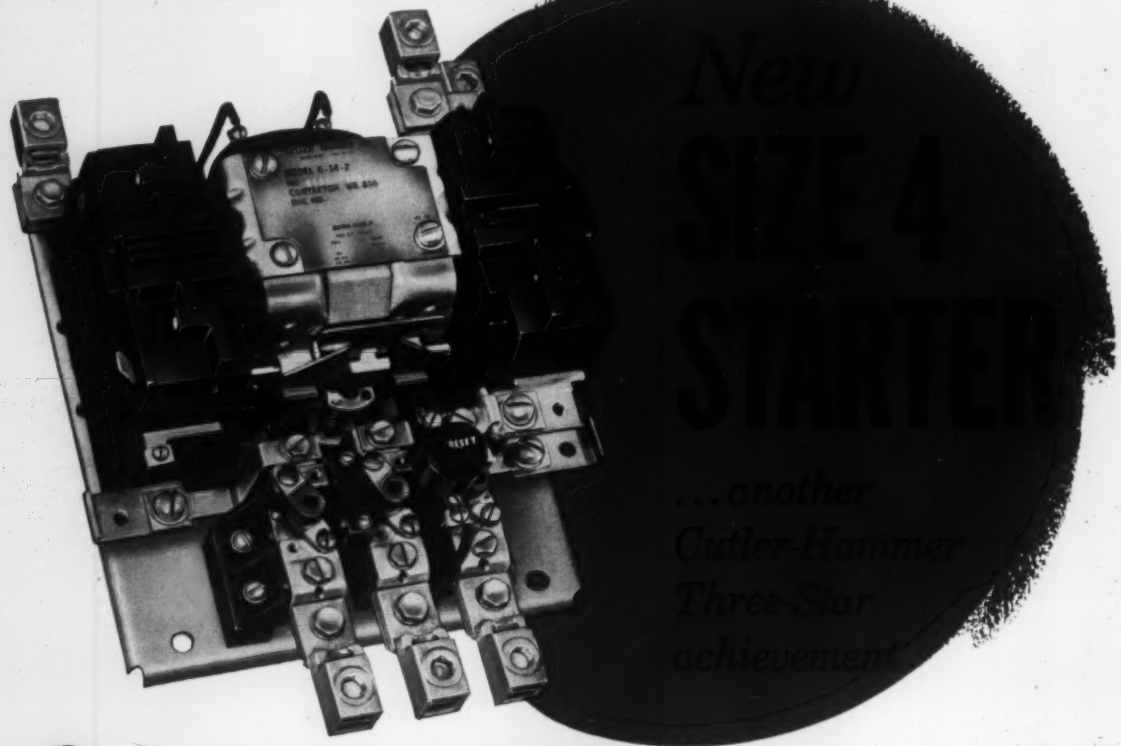
50 Hp 220 Volts, 100 Hp 440/550 Volts Max. Polyphase



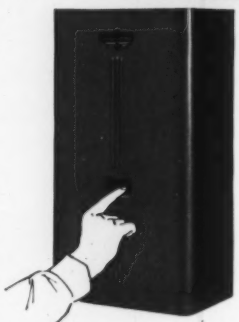
New SIZE 4 STARTER

. . . another Cutler-Hammer Three-Star achievement

compact design saves valuable panel area

parallel contact design provides increased electrical life at full capacity

low mass movable members insure superior mechanical life



This is the new Cutler-Hammer NEMA Size 4 Starter . . . industry's first large horsepower starter offering all the desired features of the famous Cutler-Hammer Three-Star Motor Control line. Smaller, more compact, this new starter simplifies control panel design and saves valuable panel area. Tests of the new parallel contact structure show vastly improved electrical life even when operated at full capacity. Further, this new design reduces the size and weight of the movable members resulting in less impact wear and unsurpassed mechanical life. We've tested it against all others, why don't you? The new Cutler-Hammer Size 4 Starter ☆ installs easier, ☆ works better, ☆ and lasts far longer. Get all the facts today. Write for the new descriptive bulletin EN125-G243. Cutler-Hammer Inc., Milwaukee 1, Wisconsin.

Look for these outstanding features . . . you'll find them only in Cutler-Hammer Three-Star Motor Control

- U-shaped cover easily removable for unobstructed inspection and accessibility
- Straight through wiring . . . line terminals at the top, load terminals at the bottom
- New pressure type terminals cut wiring time and effort
- Adjustable overload relays can be set to trip within 3% of full load motor current
- Precision cast overload sensing coils can't lose their accuracy
- Widely desired three-phase, three-coil overload protection is a standard optional feature . . . no special attachments or enclosures
- Indestructible molded magnet coil . . . color coded for positive voltage and frequency identification
- Easily installed convertible electrical interlocks require no special adapters . . . provide up to four extra control circuits
- Available as non-reversing, reversing, and multi-speed contactors and starters in the open type, NEMA 1, and all special purpose enclosures.

CUTLER-HAMMER CONTROL C-H

CUTLER-HAMMER

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Associates. Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.; Intercontinental Electronics Corporation.

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